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ELECTRIC POWER AND POWER EQUIPMENT

HYDROELECTRIC POWER STATION ON IRTYSH

Tselinograd FREUNDSCHAFT in German 4 Dec 79 p 2

[Article by Vladimir Gansha: "The Power Plant Chain on the Irtysh"]

[Text] The hydroelectric power station at Shulba, the construction of which is presently developing on the Irtysh according to the resolution of the 25th CPSU Congress, will make possible a complex use of the water reserves of one of the biggest rivers of the country.

The new power station, with a planned capacity of 1,350,000 kw, will be the third part of the hydroelectric power station chain on the Irtysh, after the power stations of Bukhtarma and Ust-Kamenogorsk, the dams of which played an important role in regulating the flow and the improvement of navigation conditions in the eastern regions of Kazakhstan that are far from a railway. The first two power stations of the chain are now producin cheap electricity for industry and agriculture in Vostochno-Kazakhstanskaya and Semipalatinskaya Oblast. The Shulba power station will be more productive than the power stations that preceded it on the Irtysh and will greatly increase the energy potential of this region of the country. Its dam will form a reservoir with a use capacity of 7.1 billion cubic meters. As a result the creation of three artifically created seas on the Irtysh--the Bukhtar, the Ust-Kamenogorsk, and the Shulba Sea--will make it possible to irrigate regularly almost 500,000 hectares of new land in the Irtysh region and to accelerate the development of irrigated farms in the northeast of the Kazakh SSR.

Thus, for example, two big land areas were chosen for irrigation from the Shulba Sea on the territory of Pavlodarskaya Oblast, where the territorial Pavlodar-Ekibastus production complex is rapidly developing. At the same time, thanks to the creation of the Shulba water construction complex, the supply of cities and villages of the republic that are in a drought-endangered zone thousands of kilometers long from the Irtysh to the industrial region of Dzhekasgan will improve.

How do things stand today at the construction site of the Shulba power station? At the lock of the dam complex they have already poured the silt-catching dams, under the protection of which water workers are pumping the pit empty and afterwards will build the pressure dam of the power station. A pit is also being dug for a lock which will make the whole upper Irtysh navigable.

To keep the natural surroundings of the Irtysh region undamaged, the original plan for the construction of the lock on the right river bank had to be changed. According to a well-founded conclusion of scientists the achieved utility would be incomparably greater than the potential ecological damage. On the right bank there is a unique relict forest; therefore it was decided to build the navigation construction on the opposite bank. The 1,000-year old pines will remain untouched.

In the vicinity of the future power station there will be a city for the energy workers which is as yet unnamed. According to the plans of the architects the facades of the houses will face the winds, which are richly spiced with the wonderful armoa of the 1,000-year old Irtysh Forest. A highway will lead from the living areas across the dam which will connect the city with a recreation area. Here in the spruce forests pioneer camps, sanatariums, kindergartens, hotels, and sports centers are being planned. All future industrial and communal enterprises will be ecologically sound.

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CSO: 1826

ELECTRIC POWER AND POWER EQUIPMENT

MODEL 1800-KILOVOLT POWER TRANSMISSION LINE DEVELOPED, TESTED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 21 Dec 79 p 1

[Article by N. Krupenik, TASS correspondent]

[Excerpts] Leningrad, December 20--All of the electric power of the Sayano-Shuskensk hydroelectric power station can be carried, with minimal losses, to the center of the European part of the USSR by a power transmission line with a voltage of 1800 kilovolts of alternating current.

Scientists of the Leningrad Polytechnical Institute completed the testing of a model of such a super transcontinental power line today.

Commenting on the significance of the experiment, Professor G. Aleksandrov, head of the department of electrical equipment, said: "When 750-kilovolt power lines were just beginning to be put into operation in our country, it was thought that the limit had been reached. Laboratory studies then indicated that air could not withstand higher voltages in its capacity as an insulator; a breakdown would inevitably follow. However, experiments conducted using original apparatus and instruments convince us that the construction of power transmission lines of still higher voltage classes is possible.

"Our scientists have developed and are testing original circuit-breakers and disconnecting switches in collarobation with design and industrial organizations. New schemes for attaching mountings and wires have been proposed, as well as recommendations which make it possible to reduce the size of substations that are being designed."

Such superelectric power lines will prove most effective in transporting electrical energy from Siberia and Kazakhstan to the Urals and the center of the country. This will require new switchgear and equipment.

CSO: 1822

MEETING DISCUSSES GENERATION OF ELECTROMAGNETIC ENERGY

Leningrad LENINGRADSKAYA PRAVDA in Russian 19 Dec 79 p 3

[Text] The search for new methods of generating electromagnetic energy and transmitting it over great distances--one of the most basic problems of modern energetics--requires the development of new materials with advanced technical characteristics for its solution. A wide range of questions in this field of science and technology is being discussed at a meeting of the section "Theoretical Problems of Generating Electromagnetic Energy" of a scientific council that has been established under the USSR Academy of Sciences' department of physical-technical problems of energetics. The meeting opened yesterday.

The solution to problems connected with carrying out a large volume of scientific research work involves leading research centers and industrial enterprises of the country, whose representatives are participating in the two-day meeting in Leningrad. Opening it, academician I. A. Glebov, chairman of the section, noted that progress in the field of materials science determines successes in electrical machine building. This work involves reducing the amount of metal used in electrical machines, increasing the machines' efficiency, and increasing the reliability of equipment.

The meeting's participants will discuss results of research and development work and will outline future directions of growth in power machine building.

CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

BRIEFS

PUMPING STATION IN GEORGIA--A new pumping station that was put to work in the Kantala Valley of Georgia saved the extensive area Malkhasis-Zveri from drought. Water from the Kura rises here by means of pipes to a height of 100 meters. Presently there are 200 pumping stations in Georgia conducting water to 80,000 hectares of kolkhoz and sovkhoz farms. That is one-fourth of all irrigated areas in the republic. In the next years the village landscape will change even more: A project has been worked out to dry out 35,000 hectares of land that is too wet in the Kolkhis Valley. [Text] [Tselinograd FREUNDSCHAFT in German 4 Dec 79 p 1] 9232

CSO: 1826

ECONOMIC MECHANISM OF THE SECTOR

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 pp 1-3

[Article: "Improvement of the Economic Mechanism — the Program of the Sector"]

> [Text] "Take steps toward further improvement of planning. Give fuller consideration to society's needs in plans and envision satisfaction of them with optimally efficient use of labor, material, and financial resources. Insure plan balance based on improvements in the system of physical and cost balances and balances of production capacities and labor resources." (From the document "Basic Directions of Development of the USSR National Economy for 1976-1980")

The decree of the CPSU Central Committee and Council of Ministers entitled "Improving Planning and Strengthening the Influence of the Economic Mechanism on Raising Production Efficiency,Work Quality" was a major step along the basic paths to improvement of the economic mechanism as outlined by the 25th party congress.

The board of directors of the Ministry of the Gas Industry received this document as a consistent guide to action and obligation to perform, considering its implementation as a crucial national economic challenge.

In conformity with the decree, the Ministry of the Gas Industry prepared and issued an order which outlines the development and implementation of a set of steps in 1979-1980 to raise the level of planning work, step up the launching of production capacities, raise the efficiency of capital investments, further economic accountability, and bolster the role of economic levers and stimuli in the gas industry.

Realization of this document will permit the following:

1. an enlargement of the role of the five-year plan as the principal form of sector planning and

basis for organizing the economic activities of associations, enterprises and organizations;

2. an improvement in the substantiation of plans by making economic and engineering calculations of production volume and material, labor, and financial resources;

3. an acceleration of the introduction of scientific-technical advances aimed at increasing the rate of growth of labor productivity and product quality;

4. an improvement in the level of planning for capital investment and material-technical resources, striving for a strict balance between them and production volume;

5. development and broad introduction in planning of scientifically substantiated technical-economic norms and standards for all types of jobs, labor inputs, raw and processed materials, fuel and energy resources, and the like.

The Board of Directors urged the managers of administrations and divisions of the central administrative apparatus, associations, enterprises, and organizations to insure hard work to implement all the steps envisioned by the order towards further improvement of the economic mechanism of the sector.

The Ministry of the Gas Industry has begun working out a statute on procedures and time for compiling long-range and current plans of economic and social development of the gas industry. These plans will include: special-purpose comprehensive scientific-technical, economic, and social programs; programs for the development of particular regions and territorial production complexes; plan balances and techniques for calculating available production capacities and fixed capital; summary plans for modernization and technological re-equipping of existing enterprises, including activities financed by the fund for production development, with calculations of the need for capital investment and equipment.

To strengthen the normative method of planning proposals are being prepared on a system of plan indexes and economic norms that most accurately reflect the course of production and rise in its efficiency and labor productivity in the gas industry.

The All-Union Scientific Research Institute of Economics, Organization, Production, and Technical-Economic Information in the Gas Industry is preparing to formulate methodological principles for sectorial planning in the gas industry and development of the technical, industrial, and financial plan of the production association.

Work is underway on formulation of an identification document for the production association to improve the substantiation of ministry plans. This document will have data on the availability and level of use of production capacities (including the shift coefficient of equipment), organizational-technical level, production specialization, and other technical-economic indexes.

This identification document will become the only criterion of the level of development of the enterprise and description of its production potential.

In the current year the Ministry of Gas Industry will send the State Committee for Science and Technology the proposals on evaluating the technical level of machinery and equipment being produced for the industry. These proposals will be aimed at development and implementation of steps to raise the technical-economic indexes of this equipment and equipment being manufactured for the first time. They will also suggest the withdrawal of outdated output from production.

The ministry will also prepare and send to the State Committee for Science and Technology proposals on procedures and times for conducting non-departmental expert examination of the technical-economic indexes of especially important types of output and industrial processes in the stages of technical specifications and final results.

In the first quarter of 1980 the Ministry of the Gas Industry will review and ratify the procedure for development and performance of a comprehensive program of scientific-technical progress in the sector.

Work will be done in 1980 to switch scientific research, design, and experimental enterprises and science-production and production associations and enterprises of the Ministry of the Gas Industry to the economic accountability system of work organization with respect to developing, incorporating, and introducing new equipment on the basis of invoice orders (contracts).

With this goal in mind, proposals will be prepared in the first quarter of the coming year on the procedure for switching scientific research and planning-design organizations to a system of charging by jobs completely finished and accepted by the purchaser.

Proposals are under development, based on a revision of outdated standards and technical specifications for materials, machinery, instruments, and equipment used in the sector, to include them in state plans for standardization. A special area of ministry activity will be participation in the development of comprehensive programs to standardize consumer goods turned out by enterprises of the sector.

The Ministry of the Gas Industry is organizing development of a system of progressive technical-economic norms and standards for types of jobs and expenditures (savings) of raw and processed materials and fuel-energy resources, and norms for the use of production capacities in the 11th Five-Year Plan.

Providing for a guaranteed stock of material resources is an important step in substantiation of plans for development of the sector. Proposals for normative reserves have been prepared and submitted to USSR Gosplan and USSR Gossnab.

Steps will be taken in 1979-1980 to prepare basic estimates and norms to be used in a gradual transition during the 11th Five-Year Plan to planning labor productivity at construction and installation organizations on the basis of net (normative) output or another index that more exactly reflects changes in labor inputs.

At the same time, standards of labor and specific capital investment for the 11th Five-Year Plan and methodological instructions on determining long-term wage norms per ruble of output are being developed.

The Ministry of the Gas Industry is taking steps to raise the efficiency of capital investment, step up the launching of production capacities and projects at construction sites begun earlier, and sharply reduce the number of new construction sites undertaken in order to bring the volume of incomplete construction within established norms in the near future.

Beginning in 1981 a transition will be made to five-year planning of planning and surveying work.

After 1981 charges between customers and planning-surveying organizations will be made for completely finished plans, accepted by the customer, for the construction of enterprises, priority complexes, stages, and installations.

The introduction of payments between customers and contractors for completely finished construction jobs, enterprises, priority complexes, and stages that have been turned over for operation, and services rendered according to the estimated value of the commodity construction output will be completed in 1981.

The ministry is working to switch in 1979-1981 to the two-level and three-level systems of management. This will make it possible to single out production construction-installation associations, and in some cases trust, as the primary economically accountable elements of construction work.

In 1980-1981 the Central Norm Research Station of the Ministry of the Gas Industry is to carry out steps toward broad development of brigade forms of labor organization and stimulation in all production and industrial associations, in trunk oil pipeline administrations, construction, and other spheres of activity, bearing in mind that brigade-type labor organization must become the primary form in the sector during the 11th Five-Year Plan.

Toward this end the administrations, divisions, and associations will prepare proposals in the first quarter of 1980 indicating the specific production sectors in which brigade forms of labor organization must be developed, the production functions of the future brigades, and suggestions with respect to organizing collective forms of labor stimulation. At the same time recommendations will be formulated for production brigade councils with regard to determination of the amount of bonuses and earnings paid for the work results of the entire brigade collective taking into account the actual contribution of each member of the brigade to the overall work results. A procedure will be defined to establish pay supplements to brigade members for professional skills, combining occupations, and raising a worker's job rating with due regard for work quality.

Proposals are being developed to bolster the stimulating role of bonus systems, which are expected to insure a rise in production efficiency and work quality. The statute on bonus payments is being brought into line with the procedure for formation of the material incentive fund and criteria for evaluating the activity of production associations, enterprises, and organizations.

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FUELS AND RELATED EQUIPMENT

SIBERIA'S ROLE IN THE COUNTRY'S FUEL AND ENERGY COMPLEX

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian No 5, Sep-Oct 79 pp 863-874

[Article by A. A. Makarov, Moscow]

[Text] At present and in the foreseeable future Siberia will be the main fuel base of the country, providing an efficient increase in fuel and power to suply both internal needs for these types of resources and the main export requirements. Two qualitatively different stages in Siberia's performance of this role may be distinguished. In the first, the task will be to draw the Siberian resources in question into the country's fuel and energy complex (TEK) as fast as possible, owing to their great effectiveness and a certain tension in the fuel and energy balance. In the second stage the most important task will be long-term maintenance of economically justifiable levels of production of Siberian energy resources during a transition from "worked out" fields and basins to new and perhaps less effective ones in a way which is least difficult for the national economy. These two stages clearly are closely connected, but the methods of studying them are significantly different. Below we discuss primarily the first of them.*

1. Methods of Studying the Direction of Development of the Fuel and Energy Complex

Siberia's fuel resources have the country's best economic indicators as regards extraction, but most of them must be transported a distance of 3,000 kilometers or more. In combination with great expenditures on infrastructure, this will place a heavy burden on the national economy, particularly during the first stage of development of the resources. A lessening of this burden will result from scientific and technical progress and an effort to move energy consumers to fuel sources to the extent possible. But in the near term these directions cannot be fully realized, and accordingly the national economy's capabilities for transporting fuel from Siberia into the European parts of the country will also govern production volume.

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* Reference 1 describes several problems of the second stage.

Finding the optimal directions for long-term development of the fuel and energy complex requires solution of three main groups of problems (Fig. 1): 1. Forecasting rational dimensions and structure of the fuel and energy demand in the national economy; 2. Calculation of economically justifiable capabilities for fuel production in the main fields and basins over the long term; 3. Optimization of the production structure of the fuel and energy complex with allowance for the territorial and technological characteristics of its sectorial systems and also for scientific and technical progress.

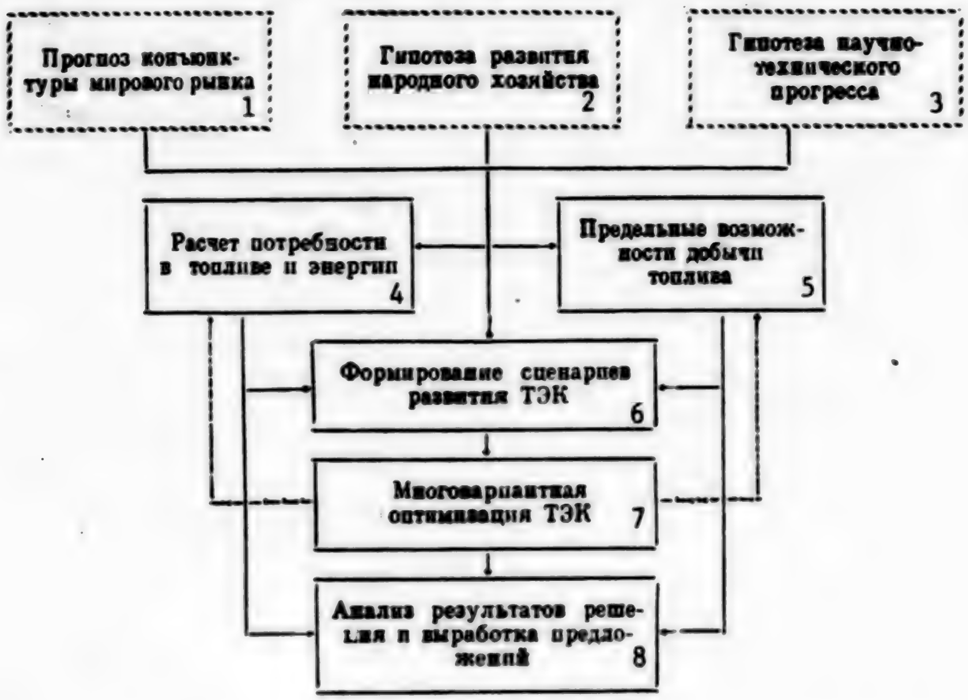
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Diagram 1. Study of the Optimal Directions of Development of the Fuel and Energy Complex

Key: 1. Forecasting world market prices
2. Hypothesis of national economic development
3. Hypothesis of scientific and technical progress
4. Calculation of fuel and energy demand
5. Maximum possible fuel output
6. Formulation of scenarios for development of the fuel and energy complex
7. Multivariate optimization of the fuel and energy complex
8. Analysis of solutions and development of proposals

Determining the national economy's demand for fuel and energy (as a whole, and broken down by energy carriers and territorially) is a complex and largely not yet formalized process. Its complexity stems from the all-pervading nature of energy, the multiplicity of its forms and the methods for using it, and the extensive interchangeability (particularly in the long term) of these forms with materials and labor. The last-mentioned characteristic explains a certain

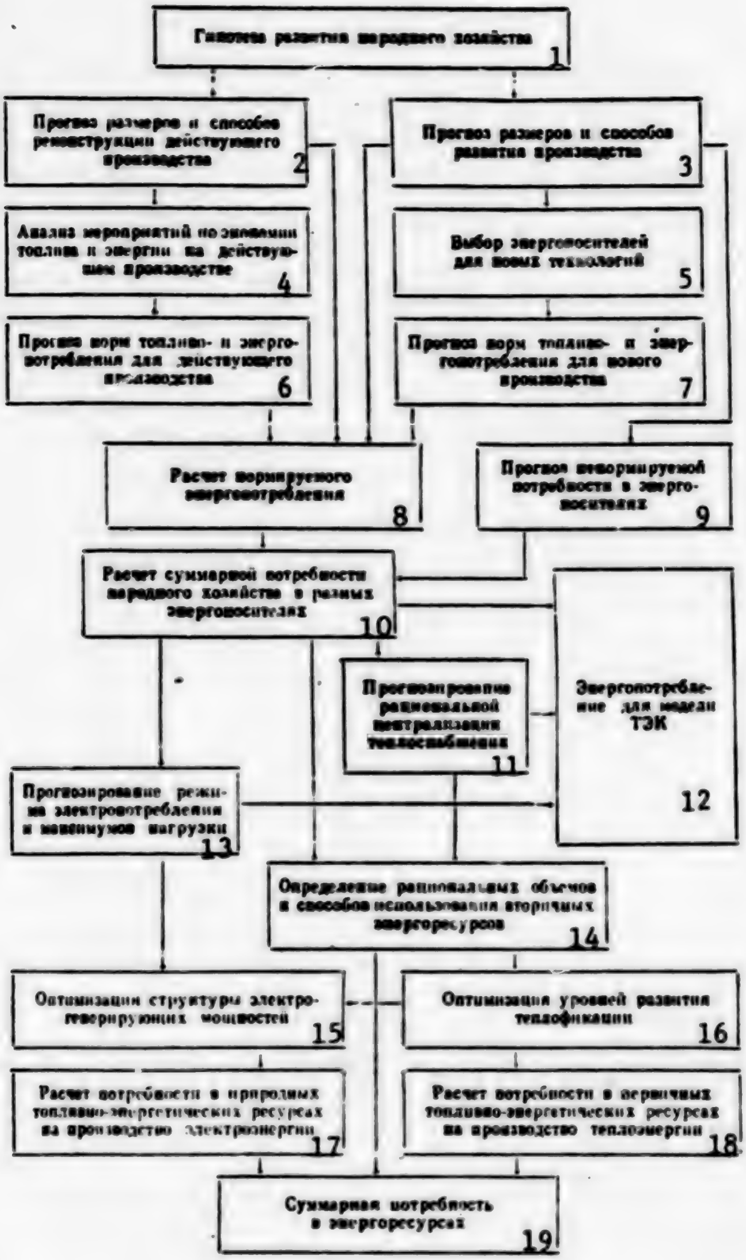
Гипотеза развития народного хозяйства 1
Прогноз размеров и способов реконструкции действующего производства 2
Прогноз размеров и способов развития производства 3
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Diagram 2. Main Stages in Forecasting Energy Consumption by the "Direct Accounting" Method.

Key to Diagram 2:

1. Hypothesis of development of the national economy
2. Forecasting of extent and methods of reconstruction of existing production
3. Forecasting of extent and methods of developing production
4. Analysis of measures aimed at saving fuel and energy in existing production
5. Selection of energy carriers for new processes
6. Forecasting of fuel and energy consumption norms for existing production
7. Forecasting of fuel and energy consumption norms for new production
8. Calculation of energy consumption per standards
9. Forecasting of demand for energy carriers according to norms
10. Calculation of national economy's total demand for various energy carriers
11. Forecasting of rational centralization of heat supply
12. Energy consumption for model of fuel and energy complex
13. Forecasting of energy consumption conditions and maximum loads
14. Determination of rational quantities and methods of utilization of secondary energy resources
15. Optimization of the structure of electrical generation capacities
16. Optimization of the level of development of heat supply
17. Calculation of demand for natural fuel and power resources for production of electricity
18. Calculation of demand for primary fuel and power resources for production of electrical energy
19. Total demand for energy resources

elasticity (increasing over time) in the energy demand as a whole and particularly in the demand for individual types of energy, and as a result the strong dependency of the dimensions and structure of the energy demand on the total and comparative economic feasibility of production of various energy resources.

In long-term calculations, good results in determining fuel and energy demand are given by the so-called "direct accounting" [pryamoy schet] method* (Fig. 2).

This makes it possible to calculate total demand by means of a forecast of energy consumption norms and the levels of output of 60-80 types of goods and services corresponding to a given hypothesis of development of the national economy (for more details see reference 2). But the selection of optimal energy carriers (electricity, steam, hot water, fuel for direct use), i.e. of the structure of overall demand, is done in terms of several dozen energy-consuming processes, by means of complementation costs [zamykayushchiye zatraty] for fuel and electrical energy. These are then refined in optimizing the fuel and energy complex, which entails iterative correction of the dimensions and structure of energy demand (see Fig. 1).

Forecasting the economically justifiable fuel output possibilities (by type and region) is also far from complete formalization, although another energy demand forecast has been proposed in this connection. It includes, first, a geological evaluation of potential fuel reserves by regions (oil-gas provinces and coal basins), second, a forecast of commercial fuel reserves, and third, the time trend of output levels themselves. The second and particularly the third components of the forecast are largely governed by economic factors: expected costs for development of fields, and the effectiveness of utilizing the fuel from a given province or basin the the country's fuel and energy complex. This last, as in the forecasting of energy consumption, is estimated by means of complementation costs for fuel, but for these purposes they must be specified not uniquely but as functions of the extent of use of fuel from the region in question (as a time trend) in the fuel and energy complex. Some approaches to calculating an optimal time trend for extraction of fuel in a given province or basin are described in reference 1.

Both the demand and the possibilities for production of fuel and energy resources in the long term can be evaluated as rather broad ranges of values. The non-uniqueness of the forecast results from differences among the hypotheses of the development of the national economy and from the effect of many other undetermined factors, particularly specific developments in scientific and technical progress.

For each national economic hypothesis there is a rather definite connection between energy consumption and the production of energy resources[3] (although the other undetermined factors blur it, bringing it down to the level of correlation between the specified indicators), Accordingly a top-priority task in selecting the optimal directions for development of the fuel and energy complex is evaluation of the real possibilities for extraction of the main types of fuel for different energy consumption levels in the national economy (for two or three development hypotheses), i.e. the development of noncontradictory scenarios for the development of the fuel and energy complex (see Fig. 1).

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* This must still be supplemented by other methods, especially extrapolation and regression models for forecasting energy consumption.

** High levels of energy consumption correspond to a high pace of development of the national economy and thus to greater capabilities for mastering resources.

The solution of this problem will answer the question of what resources the national economy can (for each hypotheses) allocate for development of Siberia's fuel bases, making allowance for the transport of fuel into the European regions. A tool for this is the dynamic model of development of the fuel and energy sectors (with a breakdown of the country into three zones: the European part, Siberia-Far East, and Kazakhstan-Central Asia) in interconnection with the supporting sectors: ferrous and nonferrous metallurgy, various types of machine building, construction and transport. Intersectorial connections are described in the model in natural measurements for 25 types of nonenergy products. The possibility of international trade is provided for in the case of both products and fuel. The target function is written in the form of the minimum discounted sum of effective costs [privedennyye zatraty] for the development of the group of sectors in question under the condition that the remainder of the national economy's demand for their products be satisfied, according to the developmental hypothesis which is assumed. The model and the results from study of it are described in reference 3.

Calculations using the model for each level of energy consumption are used to determine the time trend and possible ranges of optimal levels of output of the main types of fuel. These ranges characterize the real extent of interchangeability of these types of fuels (and accordingly of the main fuel bases) with allowance for both the internal structure of the fuel and energy complex and for reorganization of associated sectors of the national economy. Fig. 1 shows the relative possibilities for interchangeability of of Tyumen' gas and Siberian coal [reference 2, page 155]. Here the optimal proportion of gas and coal in the fuel and energy complex for one of the hypotheses for development of the national economy is taken as the basis for division of the ordinate. As can be seen, the possibility for large-scale use of gas is extremely limited: less than 1 percent of the total output of energy resources in the country. A decrease in its use (with replacement by coal) is simpler to achieve and can be done in a wider range the longer the period of the forecast. This provides an evaluation of the real inertia of the fuel and energy complex reproduced among other things by associated sectors of the national economy.

Within the energy demand levels that have been determined and the ranges of development of the main fuel bases which have been determined for them, a multivariate optimization of the territorial and production structure of the fuel and energy complex is carried out. For this purpose, a detailed model is used, optimizing the extent of production, processing, transporting and conversion of all types of fuel and energy resources and also their distribution over the main categories of consumers. Thus we determine: the inputs of production capacities by type of product in the fuel and energy complex; the carrying capacities of specialized transport; and the main steps associated with implementation of the achievements of scientific and technical progress, the fuel regimes of various categories of consumers (differentiated by region of the country) and also the ranges of values for complementation costs for fuel and energy.

The variation of external conditions requires special selection of the alternatives for development of the fuel and energy complex to be optimized and special methods for analyzing the resultant solutions so that the variants chosen not only will give the required effectiveness but will also be workable in a variety of situations. Procedures for such analysis are described in references 2 and 5. Their essence is that from the alternatives for development of the fuel and energy complex which are optimal for the various possible conditions, a new combined alternative is formed. This comtains not only measures (and facilities) which are common to all the optimal variants but also (not, as a rule, exhaustively) what would seem to be mutually exclusive groups of measures which could be developed to the required scale as the applicable situation arose. Thus the system is given a certain reserve of flexibility which will make it easier to adapt as the conditions of development become more precisely known.

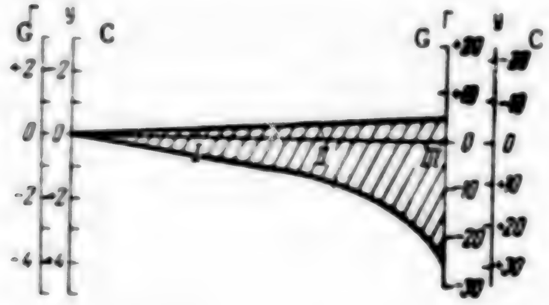

Fig. 1. Relative interchangeabilities of Tyumen' gas (G) and Siberian coal (C). The left-hand scale gives the percentage of total output of energy resources by stage; the right-hand scale gives the percentage of the deviation within the optimal output of fuel in Siberia for the five-year plan.

The additional expenditures for flexibility and the savings from adaptation of the best system are made commensurate not by means of the entire payment matrix for decision-making in indeterminate situations (see reference 5), but only in terms of specially chosen columns of the matrix (reference 2, appendix 3). This not only makes finding a solution less time-consuming, but also makes it possible to develop a relatively reliable strategy for developing the fuel and energy complex.

2. Some Results of Investigation of the Role of Siberia in the USSR TEK

The mathematical apparatus described here has frequently been used to discover possible directions of long-term development of the USSR's fuel and energy complex. In these, the following factors have been varied: the levels of production and consumption of the main energy resources, their territorial distribution, the sizes of fuel and energy overflows and the like. Certain stable relationships in the development of the USSR fuel and energy complex have been identified and may be considered as its objective tendencies.

The restructuring of the fuel and energy balance to increase sharply the share of oil and natural gas, which began in the late fifties, constituted a scientific and technical revolution in power production and produced a great national economic effect. As a result, since the late fifties high-quality types of fuel have taken on primary importance in the production of energy resources. Subsequently the share of high-quality types of fuel has been stabilizing in a regional fuel-energy complex structure, while high absolute growth rates in their production have been maintained (Fig. 2 (reference 2, page 197)). This has been caused by several factors. One of of them is the relatively limited character of explored reserves of oil as well as of the possibilities for using natural gas. At the same time, the achievement of a level of supply of high-quality fuel to the main categories of consumers which is satisfactory if not fully rational may be considered an essential factor in stabilizing the share of high-quality fuel in the production of energy resources. Indeed, as the share of high-quality types has stabilized at 2/3 of total production, the most effective areas of its utilization have become saturated with them; these are: manufacturing and municipal-domestic needs, as well as small and medium-size power plants (transport and nonstationary facilities in construction and agriculture are already almost fully satisfied). Let us note that in the future the share of industrial, transport and domestic needs in fuel consumption will decrease as the national economy becomes more fully electrified.

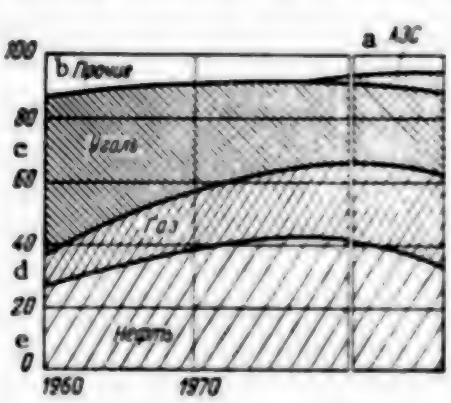

Fig. 2. Share of various types of fuel in total production of energy resources.

Key: a. Nuclear power stations
b. Other
c. Coal
d. Gas
e. Oil

A different policy is advisable as regards electric power stations. Here the predominant role should go to nuclear power, which will supplant other types of fuel in providing for the increase in the basic electrical load and may possibly do so ultimately for heat-supply capacities as well. Then, if we exclude consumption of high-quality fuel by existing power stations, whose capacity will decrease as obsolete equipment is removed, it will be consumed only by specialized equipment (peak gas turbine equipment and the superstructure of steam and gas power stations which provide flexibility) and for the remaining new TETs within the cities. A certain quantity of high-quality fuel will also be required for existing and new power stations inside the cities, although subsequently they will be actively supplanted by nuclear power stations.

The abovementioned trends in provision of fuel to consumers should be recognized as progressive, as a result of the rationality of stabilizing and subsequently gradually decreasing the share of high-quality fuel in the structure of the fuel and energy complex. But policies regarding oil and gas should differ significantly. A complex of external conditions (availability of resources, the energy market situation and the like) should be taken into account in pursuing a rigid policy of relative decreases in the use of oil as a power production fuel (see Fig. 2). The rate of this process is determined by the possibilities for increasing the capacities of secondary processes for refining it and for increasing the capacity of gas storage installations to regulate seasonal nonuniformities in fuel consumption, i.e. to carry out the functions which are currently performed by heavy fuel oil [mazut]. Meanwhile, in the foreseeable future heavy fuel oil will remain the peak fuel used for certain industrial needs.

As utilization of oil decreases, the role of gas in the balance will increase: during the first stages on a scale which completely compensates the decrease in oil's share, and thereafter at a slightly slower rate. This will require great efforts, not only in the traditional areas of gas extraction and transport, but also in its storage and distribution to increasingly scattered consumers.

It is important to stress specially that the restructuring of the USSR's fuel and energy complex as regards consumption of high-quality fuel is being carried out with a simultaneous increase in the share of nuclear power, so that the qualitative structure of the fuel and energy balance is continuing to improve steadily.

As a result of the transformations in the structure of the fuel and energy complex that have been described, coal's share will be stabilized at 24-26 percent. While it loses its position in the European part of the country, coal will fully maintain it in Siberia, whose role in the fuel and energy balance will be increasing.

An extremely important characteristic of the development of the USSR's fuel and energy complex is the transfer to the eastern parts of the country, primarily Siberia, of practically the entire increase in output of organic fuel.

It is important to stress that in the current stage of scientific and technical progress and with the currently explored reserves of fuel such an orientation is the most justifiable one economically. At the same time, it requires the creation of a production structure for the fuel and energy complex which differs fundamentally from that which prevailed before the beginning of the sixties when, with reliance on local and zonal fuel bases (the latter of which included even the Donbass and Kuzbass), the problem of fuel supply was reduced primarily to that of extraction. We assume that in the long term the role of the transport link in the fuel and energy complex will increase sharply and will change qualitatively. Currently fuel transportation (rather than extraction) conditions determine not only the development of individual fuel bases and the situation of fuel supply to consumers, but even the structure of the fuel and power complex as a whole. Meanwhile transport is becoming increasingly specialized, which is converting it from a component part of the national transport system to an organic link in the fuel and energy complex.

Thus the new developmental trend of the fuel and energy complex is its conversion into a unified transport-power production system taking in practically the entire economically developed territory of the country in a great and steadily strengthening network of main and distribution energy lines (pipelines and electrical power lines). This will confer on the fuel and energy complex the characteristics of not only an economic but also a unified physical and technical system, which will have a considerable effect on the conditions of its organization and operation.

The quantitative manifestations of this new character of the fuel and energy complex will be governed in specific terms by the solution of one of the most difficult problems of development of this country's power engineering: the selection of efficient means of fuel and energy supply to the European regions of the country. In spite of the shift to the eastern regions of the main growth in energy-intensive production activities and a portion of their accompanying activities, the European part of the USSR will remain the chief consumer of fuel and energy.

This disproportion in the distribution of the increase in fuel extraction and consumption results from the trend, shown in Fig. 3, in providing consumers in the European part of the USSR with intrinsic and shipped-in energy resources. The stabilization of the absolute dimensions of fossil fuel extraction in the European part of the country requires a continuing increase in the share of energy resources obtained from the eastern regions, which even if the majority of nuclear power stations are concentrated in the eastern part of the country will amount by the end of the period in question to half of all energy consumption and will increase thereafter as well. The corresponding trend in the flow of fuel and energy resources from the eastern regions of the country to the European ones is shown in Fig. 4 (reference 2, page 201). The severalfold increase in the flow of energy resources from the eastern regions of the country will constantly increase the role of specialized transport. Here the most reliable solution is to focus not on some single type of transport but on a rational combination of the main types of mass transport: pipeline, railroad and electrical systems.

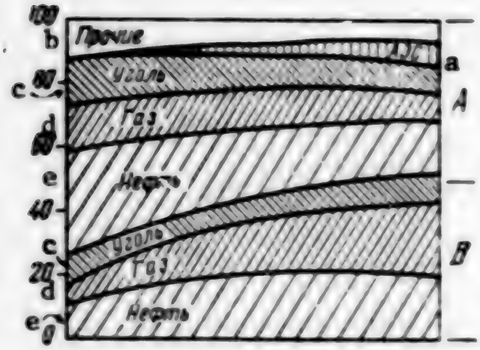

Fig. 3. Trend of provision to consumers in the European part of the USSR of indigenous (A) and shipped-in (B) energy resources, percent, long term.

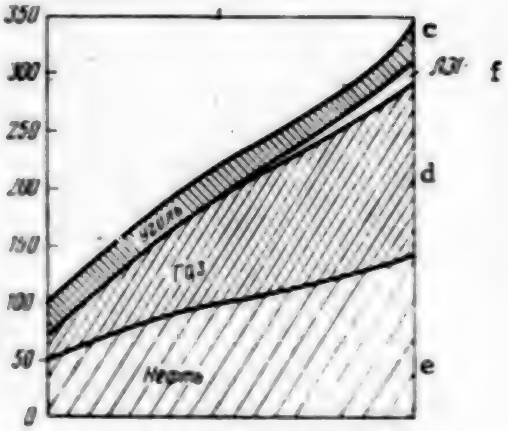

Fig. 4. Trend of flows of fuel and energy resources from the eastern regions to the European ones, percent, long term.

Key to both figures:

a. Nuclear power
b. Other
c. Coal
d. Gas
e. Oil
f. Power lines

The almost complete transfer of oil output growth to the eastern parts of the country (primarily to the most difficultly-accessible and climatically harshest ones) will sharply increase expenditures on transport of fuel and energy resources. In combination with the increasing absolute growth rates of energy resource production, this will require in the upcoming period greater capital investments and expenditures of material resources on the development of the fuel and power sectors. It is important to stress that the increase in capital and material intensity of the fuel and energy complex in the upcoming stage is an objective necessity resulting, by no accident, from a concurrence of circumstances or market considerations and from long-term developmental tendencies of the national economy and of the mastery of natural resources of the USSR. However, there are realistic ways of slowing the increase in capital and material intensity of the complex by rationalizing the production structure of the fuel and energy complex and the distribution of fuel and energy consumers, as well as by accelerating scientific and technical progress in power production.

measures. To determine the full range of these and then to implement them requires development of a comprehensive program. Here we should distinguish two types of programs. The leading programs are production programs, which generally intensify the development of various links of power production that promise the greatest national economic effect. In most cases such production programs are localized in a specific territory (e.g. the Kansk-Acninsk mining and energy industry complex), but thay may also be structured in terms of an industrial characteristic (e.g. a program for developing nuclear power production). In any case, we have in mind major energy-economy measures leading to quantitative growth and structural improvement of the fuel and energy complex as a whole.

Implementaion of production programs in turn requires a complex of measures of a scientific and technical character leading to radical improvements of existing technical facilities and development of new ones. For example, creation of the Kansk-Achinsk complex requires mastery and series production of coal-fired power production blocks with capacities of 0.8 to 1.6 million kilowatts and a DC power transmission line: without these the complex would be incomplete and much less effective. Such measures constitute the scientific and technical programs for the development of power production. The methods of developing production and scientific-technical programs are essentially different, and only programs of the first type are discussed below.

The composition of a production program is determined directly by the results of optimizing development of the fuel and energy complex. The feature which serves to distinguish a program from the entire range of power production solutions obtained by optimization is: unity of purpose, precise and specific formulation of the purpose, and an industrial and frequently territorial interconnection (intercausation) of the various measures. At the same time, the correct formulation of a program still is by and large and art.

For the time span we are considering, we feel it is advantageous and possible to implement the following main production programs for development of power production: 1. mastery of the West Siberian oil-gas province; 2. creation of the Kansk-Achinsk mining and power industry complex and the closely associated development of the Kuzbass; 3. development of nuclear power production to the economically justifiable limit; 4. development of the Ekibastuz coal and power production complex.

Below the main features of the first of these programs are considered by way of example. Mastery of the West Siberian oil-gas province with expansion to the economically justified level of oil and gas output is clearly one of the USSR's greatest economic programs. It includes: exploration and extraction of the requisite quantities of oil and gas; their distribution by means of special-design gas pipeline systems as far as the Far East and Western Europe; the development of an immense industry for the refining of oil and casing-head gas and the recovery of gas condensate, as well as petrochemical complexes relying on the raw materials thus obtained; and additional development of metallurgy and machine building in order to supply pipe, equipment and materials to the petroleum, petroleum refining and petrochemical industries as well as to create the necessary infrastructure in underdeveloped regions of West Siberia.

The most efficient dimensions of oil and gas extraction in West Siberia are determined through multivariate optimization and factor analysis of the conditions of development of the fuel and energy complex. In the time span under consideration, the economically justifiable level of oil extraction for the country must be reached primarily by an increase of output in West Siberia. The situation regarding the output of Tyumen' natural gas is similar.

The optimization calculations make it possible to estimate the total economic effectiveness of the program for mastering the West Siberian oil and gas province. Table 1 gives the aggregate characteristics of the main components of the economic effect from utilization of West Siberian oil and gas. Even in the first period of its development, the West Siberian oil-gas province as a whole is giving a net saving (profit) and paying back all expenditures incurred, including development of the regional infrastructure, two to three times over.

The refining of the oil and gas is an important component of the program for development of the West Siberian oil-gas province. Refining of oil and casing-head gas in gas refineries and the "drying" of gas from gas condensate fields is provided for. Calculations indicate that the utilization of petrochemical raw materials from the casing-head gas and the transferring to Siberia of the production of raw materials for petrochemistry in oil refineries are likely to give a large economic effect along with a significant improvement in provision of fuel to small consumers in Siberia.

Delivery of the extracted oil and particularly gas to consumers is the most complex part of the program for development of the West Siberian oil-gas province. Delivery of fuel outside of Siberia to consumers in the European regions of the country and for export requires a specially designed pipeline system. Its development will require annual construction of 2,500-3,000 kilometers of large-diameter gas pipeline with the full complement of compressor stations and the requisite system of branches, and construction of a similar oil pipeline every three years. In addition, further measures will be required for transport of oil and gas for export.

The measures in support of this program include performance of the required amount of exploratory work (primarily for oil) and early development of production capacities in metallurgy, rolled stock production, machine building and the construction industry. The specified quantities of exploration work and the future trends of oil and gas extraction in West Siberia, as well as transport to the European part of the country by pipeline, have been estimated in terms of the expenditure of various types of national-economic products for the purpose. For this purpose we determine the direct and associated costs of the major types of products for extraction and distribution of

Table 1. Aggregated estimates of savings on expenditures (or net profit) from development of the West Siberian oil-gas province.*

Экономия 1	В % от общей суммы экономии 2
3 На добыче и транспортировке замещаемых сибирских углей	45
4 На использовании топлива потребителями, в том числе	22
5 на электростанциях	16
6 остальным потребителям	6
7 Прочие статьи	33
8 Итого:	100

Key:
1. Saving
2. Percent of total saving
3. On extraction and transport of Siberian coal replaced
4. On use of fuel by consumers, including
5. Electric power stations
6. Other consumers
7. Other items
8. Total

* The total effective costs include a 15-year period for reaching the specified level of development of the province. A further considerable saving will be realized in the subsequent period of operation according to norm.

West Siberian energy resources and the production capacities required to produce these items year by year for the period in question. Table 2 presents certain results of this computation. These take only partial account of expenditures for creation of infrastructure and exclude expenditures on oil refining, petrochemstry and gas refining. But even to this incomplete extent, the program for mastery of the West Siberian oil-gas province will require extremely great material expenditures. Comparing them with the current level of production of the items in question, the implementation of the program will require more than half of the total production capacity for building materials and 1 1/2 times more cast iron, steel and rolled stock. The requirement for pipe exceeds current output severalfold (reference 2, page 213). Extensive development of the oil and gas industry must also be preceded by development of large productive capacities in other associated sectors: plants for the production of compressors, large pumps and electric motors, cement plants and the like. But all capital expenditures on implementation of the program will not only be recovered in the specified (eight year) period, but will even give, in comparison with other approaches, a saving of at least 30 percent of all expenditures on the utilization of West Siberian oil and gas. This great additional saving enables us to consider the program for development of the West Siberian oil-gas province not only as immense, but also as one of the most effective such programs.

Table 2. Approximate requirement for industrial products for development of the West Siberian oil-gas province [reference 2, page 214].

Вид продукции a	Потребность за период b	В том числе по пятилетиям c	
		первое d	второе e
f 1. Черная металлургия			
g чугун, млн. т	125	50	45
h сталь, млн. т	210	80	75
i прокат, млн. т	175	65	60
j трубы, млн. т	130	50	45
k 2. Промышленность строительных материалов			
l цемент, млн. т	75	35	30
m сборный железобетон, млн. $м^3$	100	45	40
n 3. Специальное машиностроение			
o буровое оборудование, тыс. шт.	3,7	2,1	1,1
p газоперекачивающие агрегаты, млн. квт	25	10	10
q нефтеперерабатывающие агрегаты, тыс. шт.	1,5	0,9	0,5
r 4. Общее машиностроение			
s строительные машины и механизмы, тыс. шт.	200	100	80
t подвижной состав, тыс. шт.	100	50	40
u станки и кузнечно-прессовое оборудование, тыс. шт.	95	60	30

Key: a. Type of product
b. Requirement for the period
c. By five-year plan
d. First
e. Second
f. Ferrous metallurgy
g. Cast iron, million tons
h. Steel, million tons
i. Rolled stock, million tons
j. Pipe, million tons
k. Building materials industry
l. Cement, million tons
m. Precast reinforced concrete, million cubic meters
n. Special machine building
o. Drilling equipment, thousand pieces
p. Gas pumping units, million kW
q. Oil refining units, million pieces
r. General machine building
s. Construction machinery and mechanisms, thousand
t. Rolling stock, thousand
u. Machine tools and forging and pressing equipment, thousand

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FUELS AND RELATED EQUIPMENT

UDC 338.45:69

WAYS TO CUT CAPITAL INVESTMENT FOR WEST SIBERIAN GAS REVIEWED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 pp 4-6

[Article by A. G. Gudz', deputy minister of the gas industry: "Make Improvement in the Capital-Intensiveness of Construction Projects the Basis of Planning"]

> [Text] The primary ways to improve the management of economic construction outlined by the 25th party congress were developed concretely and in depth in the decree of the CPSU Central Committee of the USSR Council of Ministers entitled "Improving Planning and Strengthening the Influence of the Economic Mechanism on Raising Production Efficiency, Work Quality"
>
> This document, which is crucially important for further bolstering the country's economy, contains a set of interrelated steps to raise the efficiency of capital investment and accelerate the launching of production capacities and installations.

Incorporation and rapid launching of gas extraction enterprises in the unsettled, little-developed regions of Western Siberia requires efficient performance of planning and surveying work and painstaking development of technical decisions to insure minimum time of realization with optimal expenditures.

The contemporary gas extraction enterprise is a capital-intensive and metal-intensive production facility which comprises an intricate system of interrelated installations. Building such enterprises in Western Siberia involves the special features of this region: the harsh natural and climatic conditions, weak permafrost ground, lack of local work force and prepared areas for worker settlement, and virtually complete absence of infrastructure, above all a transportation system, energy base, and local building materials.

In addition, construction of field installations is greatly affected by the lack of proven methods of work on weak permafrost grounds and swampy sectors with lengthy periods of low temperatures, by the low adaptability of existing construction machinery for such conditions, and by organizational factors.

Experience with planning, building, and operating gas extraction enterprises such as Medvezh'ye and Urengoy, as well as gas transportation enterprises, makes it possible to identify the typical problems that have occurred and outlined the primary ways to reduce capital-intensiveness and raise the efficiency of construction under the conditions of West Siberia.

A comprehensive approach that considers not just the interests of the gas industry but also of other involved organizations and departments is essential for development of this region. Unfortunately, at the present time there is no one coordinating center capable of resolving the problems of comprehensive development of the region regardless of departmental and sectorial jurisdiction.

The question of establishing a comprehensive infrastructure and housing for the entire region and the issue of environmental protection are particularly urgent matters.

According to calculations by the Siberian Department of the Academy of Sciences USSR the comprehensive approach to establishing the infrastructure in this region will make it possible to save 26 percent of capital investment compared to construction of independent facilities under departmental jurisdiction.

Working out a comprehensive long-range program for the development of Western Siberia requires working out and ratifying a long-range plan for development of this region's gas industry until the year 2000.

Increasing the unit capacity of industrial equipment is one of the main ways to improve the technical-economic indexes of construction of gas extraction enterprises, making it possible to reduce capital investment, metal use, and the construction area.

The following example shows how efficient this is. During construction of the gas fields at the Medvezh'ye (UKPG-9 [comprehensive gas preparation installation No 9]) and Vyngapur deposits, by increasing the productivity of the absorbers from 2.5 to 5 million cubic meters a day it became possible to replace the two UKPG's planned earlier with productivities of 24 million cubic meters a day apiece with one unit with a productivity of 48 million cubic meters. As a result, capital investment was cut by more than 6 million rubles and 14,000 tons less metal was used.

The use of highly efficient aggregated equipment which combines the processes of separation, absorption, and fine cleaning of the gas is particularly interesting. Using this equipment makes it possible to significantly reduce the metal-intensiveness and capital-intensiveness of gas preparation installations.

The increased productivity of UKPG's makes it possible to use gas turbines of large unit capacity in booster compressor plants. Thus, technical-economic calculations in the stage of technical-economic substantiation showed that using GTN-16 gas pumping units at booster compressor station No 9 of the Medvezh'ye field and the booster compressor station of the Vyngapur field in place of the GTN-6 units used before reduces capital investment by 9-10 million rubles for each booster compressor plant.

It should be observed that special gas pumping aggregates with multistage superchargers (2-5 stages of compression in one housing) are needed for the booster compressor station. The use of such gas pumping aggregates has a substantial economic impact. Thus, installation of four GTN-16 full-head aggregates (two stages of compression in one housing) in place of eight GEN-10 aggregates working in two stages will make it possible to reduce the area of the compressor plant 45 percent, significantly simplify the utility hookup system, and cut capital investment by 25-30 percent.

Expenditures for the field gas collection network are reduced by the introduction of the cluster arrangement of wells with up to six wells in one cluster, enlarging the diameters of the loops (collector pipes) to 350-400 millimeters, reducing the length of utility lines to the wells, and using high-efficiency heat insulating materials and wells of enlarged diameters. For example, introduction of cluster well arrangement at UKPG's Nos 6, 7, and 8 of the Medvezh'ye field instead of the even grid arrangement used before made it possible to reduce the total length of the loops by approximately 70 kilometers and cut capital investment by about 5.6 million rubles. The increase in average yield of wells of enlarged diameter (to eight inches [sic]) reduces the number of wells needed for a given volume of extraction to two-fifths — three-fifths of the average yield of six-inch diameter wells; this reduces the specific capital expenditure per 1,000 cubic meters of gas extracted by one-sixth to two-fifths.

A further reduction of capital expenditures for industrial installations can be achieved by broad use of compressed-air turbines, air coolers, and northern versions of various pieces of industrial equipment to cool the gas.

The designs being worked out by the institute envision delivery of full sets of industrial equipment being incorporated by industry to construction sites in factory-assembled form, that is, in transportable modules, which makes the work of installation highly reliable and reduces construction time by cutting the volume of construction and installation work. Experience with designing, building, and operating the structures of deposits, compressor stations, trunk gas pipelines, and booster pumping plants suggests that a significant improvement in the industrialization of construction is possible by switching from delivery of equipment in individual modules or lines to delivery of full sets of factory-manufactured industrial installations including, in addition to basic industrial equipment, intershop production, electrical, and "efficiency" utility lines, monitoring, measuring, and automation equipment and devices for operator and dispatcher points, and subsidiary facilities and structures.

Further refinements of the complete module method of construction and use of new design concepts and materials promote a decrease in the capital-intensiveness and material-intensiveness of gas extraction enterprises and a rise in the the industrialization of construction. As design and construction experience demonstrates, the use of individual "box" modules with completion of assembly at the construction site and the so-called "honeycomb" method of modular construction for arrangement of auxiliary pumping plants and field facilities leads not only to an increase in the area of general plants but also to greater construction costs.

At the present time YuzhNIIgiprogaz [possibly Southern Scientific Research and Planning Institute of the Gas Industry] is developing a rough draft of an operation-servicing repair module that can be used at pumping stations with different types of equipment and in the field.

There is no longer any doubt that, where it is not necessitated by the technological isolation of the location of services, the use of "box" modules instead of common buildings leads to an enlargement of the construction area, longer utility lines, greater expenditure of materials and energy for heating, and ultimately higher construction and operating costs. In addition, the present designs of "box" modules do not afford normal working conditions for operations personnel. In our opinion, the assortment of "box" modules should be revised to reduce the scope of application of individual modules to the level of production and service operations which are difficult or completely impossible to combine with other production and service facilities.

One of the principal lines of action to raise the industrialization of construction is the use of centrally manufactured semifinished pipe pieces, fully factory-ready building design elements, industrial modules, and subsidiary "box" modules, and laying industrial utility lines on scaffolding. Another area is expanding the assortment of items used by the Ministry of Construction of Petroleum and Gas Industry Enterprises, for example divider panels, exterior panels with solid fillings, connecting parts for pipelines, ballast, and the like.

The use of computers in the design, construction, and operation of gas extraction and transportation enterprises has a substantial national economic impact. For example, the use of computers in designing the gas pipeline system from Urengoy through Surgut to Chelyabinsk made it possible to substantiate and adopt the optimal productivity, the ideal number of compressor plants, and the optimal arrangement of them for this pipeline, resulting in a reduction of capital investment by 124 million rubles. In recent times computers have handled problems of planning the construction of gas fields such as selecting optimal routes for field and interfield collector pipelines, highways, and loops, determining optimal hydraulic losses in the gas collection network considering the expenditure of compressor capacity at booster compressor plants, and selecting the optimal variation of booster compressor stations both by capacity and by type and number of aggregate units. The Computing Center of the Academy of Sciences USSR and YuzhNIIgiprogaz have begun formulating a comprehensive program to optimize construction work at gas deposits.

The role of automated control systems for the industrial process is growing steadily in the exploitation of the gas fields. For example, the automated system at the Vyngapur gas fields, developed with participation by YuzhNIIgiprogaz, will produce a total economic effect of 550,000 rubles.

At the newly planned gas fields of Yamburgskoye and the Yamal Peninsula monitoring without control consoles and direct digital control of industrial processes by means of small controlling computers of the new series will be applied.

The composition of gas extraction complexes provides not only for primary production subdivisions but also subdivisions and enterprises of auxiliary and service facilities. Based on the principles of the general management plan and prospects for development of the sector in this region, large gas extraction associations with the assortment of subdivisions envisioned by the standard structure are proposed.

Questions of the management of subsidiary and service facilities are worked out in line with the structure of the higher-ranking organization (All-Union Production Association) and also with due regard for the existing level of development of the Ministry of the Gas Industry infrastructure in the particular region. In view of the special features of the operation of gas extraction complexes (dispersion of production sites and short period of exploitation), it is not justified economically or socially to build small permanent settlements at each production site. This makes it necessary to consider the watch [tour of duty] method as the primary method with full automation of gas field facilities. It appears wise while still in the planning stage to reduce the number of employees at an industrial site to a minimum by extensive use of combining jobs and expanding service zones, and increasing the level of management centralization and automation of industrial and auxiliary facilities. This will help reduce capital investment.

Given the decrease in influx of work force, an intelligent solution to the questions of labor organization under the watch method will not only permit reducing capital investment for the construction of housing and watch complexes, but will also unquestionably have a positive effect on holding cadres, reducing transience, and raising labor productivity.

Working out planning decisions that envision a decrease in capital investment for construction of gas extraction enterprises, raising their efficiency, and launching them in operation faster with high quality construction and installation work constitute our paramount challenge.

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FUELS AND RELATED EQUIPMENT

FORECASTING OF RESERVES AND OPTIMIZATION OF REGIONAL GAS OUTPUT LEVELS

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[Text] The oil and gas industries are among the most important sectors of the fuel and energy complex (TEK) of our country's national economy. oil and gas output levels have an important effect on the long-term structure of the fuel and energy balance obtained by optimizing the development of the fuel and energy complex. Various aspects of the problems arising in the study of these effects are discussed in reference 1.

A procedure for optimizing the development of the fuel and energy complex [2] calls for a description of the increase in output of these reserves in the broad oil-gas regions (such as Tyumenskaya Oblast, Central Asia and the like) in the form of a highly aggregated piecewise-linear plot of unit expenditures for the extraction of the resource in question as a function of the size of the increase. But such a description taken together with the standard-trend description of the fuel and energy complex (in the form of static models) will clearly distort the real expenditures on the development of an oil-gas region, which may lead to a wrong choice of output level. But there are methods which make possible a sound determination, in terms of the formation of technical and economic indicators, of expenditures associated with the development of oil pools and the discovery of an optimal strategy for mastering the oil-gas resources of a region--but only when the future time trend of output levels is specified [3]. Accordingly we need a method which takes adequate account of the trend in economic indices of oil pool development and the extraction possibilities as a function of the quantities of resources in the territory in question, and which also makes it possible to determine the course of output levels in the region which is optimal for the national economy.

Statement of the Problem of Optimizing Long-Term Gas Output Levels in an Oil-Gas Region*

Determining optimal output levels for each resource presupposes knowledge of the conditions of extraction and the size of the commercial and forecast reserves of the territory in question, the methods of developing the pools and the resources associated with use of them, and also the expenditures on discovery, exploration and preparation for commercial exploitation of the resources. In addition, since the effectiveness of use of a resource depends on amount, information which makes it possible to describe this relationship is needed. Then the problem of finding optimal output levels for the resource over time can be solved by means of a model (which we will call the "regional development model") formulated as a linear programming problem. The main constraints in the model reflect the conditions for preparation and development of reserves, while the target function to be maximized is the difference between the effectiveness of using the resource and all expenditures on its extraction. The variables in the model must express the intensiveness of the methods of working the deposits, preparing reserves and using the resource over time. By the effectiveness of use of the resource we mean complementation costs [zamykayushchiye zatraty] for it in the region in question. Thus the target function of the model is in effect equivalent to an economic evaluation of the resource [4].

The dynamic function of the national economic effectiveness of use of the resource is theoretically determined by variation calculations on statistical models of the fuel and energy complex for the five-year plans of the calculation period in question. However, optimal output levels determined from development models for the fuel and energy complex and for the region may not coincide. Accordingly interaction of these models must be organized in such a way that solution of the regional development task will determine the expenditures associated with the increase in output over the five-year plan, so that the new dynamic effectiveness function can be constructed taking account of the change in expenditures.

One of the most important problems of optimizing the development of hydrocarbon fuel resource output in each oil-gas region is that of identifying the reserves available for extraction. The most reliable resource base for extraction of oil and gas is recoverable reserves which have been proven in commercial categories ($A + B + C_1$). But recently the demand for oil and gas has increased so sharply that the effectiveness of oil and gas exploration work has decreased (owing to considerably increased complexity of geographical, geological and other exploration conditions) to the extent that in many regions the recoverable commercial reserves in explored pools are clearly inadequate for long-term planning and forecasting of the oil and gas industry. Accordingly a quantitative evaluation of the oil-gas potential of individual regions has become particularly important as a base for scientific prediction of the size of oil-gas output.

As is well known [5], currently the total possible (potential) oil-gas content of the underground regions, i.e. the maximum oil-gas saturation of the sedimentary layer of the earth, is determined by means of accepted geological criteria for the prospects of individual territories of the country on the basis of generalization of geological information received up to the moment the estimate is made. Accordingly quantitative evaluation of oil-gas potential is dynamic in nature and changes over time. Here potential resources and those which have already been recovered (extracted before the time at which the evaluation is made) include both explored reserves in pools that have already been discovered (categories $A+B+C_1+C_2$) and resources that have not yet been explored (categories $C_2+D_1+D_2$) of oil and gas. The significance of the latter in providing the oil and gas extraction industries with reserves increases as the planning horizon is broadened and the role of commercially proven reserves decreases. From this stems the national economic importance of correct (reliable) evaluation of the possibilities of converting forecast resources of oil and gas to reserves in commercial categories during each time interval of the long-range planning period as a function of expenditures on geological exploration work.

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* Also applies to oil reserves.

The solution of the regional development problem may be used to calculate not only optimal regional output levels but also a strategy for developing pools and preparing reserves (geological exploration). In planning, future indices of resource availability for oil and gas extraction are generally determined as average increases in reserves achievable by the discovery of average-size wells with average amounts of prospecting and exploration work. The result is a deterministic forecast which does not take into account the indeterminate character of increases of reserves in the long term and their distribution around the average value, which in effect enables us to expect only "on the average" the attainment of the planned level, and frequently leads to major miscalculations. The reliability of such a forecast is significantly lower than the reliability of any other starting information used in forecasting oil and gas output. We have made an attempt to establish the connection between supplementary capital expenditures on exploration and the increase in assurance of achieving the assigned growth rates thereby.

Thus the problem is that of determining the standard probability distribution function of the total increase in oil and gas reserves in the region as a function of the size of capital investment on geological exploration. It is solved by simulating the process of geological exploration on a computer using the Monte Carlo method. The following main assumptions are used in developing the simulation model.

1. Th possibility of discovering oil pools in various promising tracts is considered to be independent of the spatial position within the territory in question. We note that the suitability of this assumption is strongly affected by the geological homogeneity of the region. When forecasting increases of oil and gas reserves in a large, geologically nonhomogeneous region, we have break it up into homogeneous subregions. Otherwise the figures for future increases in reserves for the region as a whole which are obtained from the simulation will be too low.

2. The complex of geological prospecting work associated with the testing of an individual promising tract (hereafter called "testing of a promising tract") is considered as a single action. Expenditures on the testing of a tract are not constant. For example, we may take into account the dependence of the number of prospecting and exploratory wells on the degree of success in the drilling, the increase in average depth of prospecting and exploratory wells as the region becomes more fully explored and the like.

3. No more than one pool can be discovered as the result of testing of one promising tract.

4. The distribution of the pools in the region by size of their reserves is log-normal with the density

$$\varphi(z) = \frac{1}{\sigma\sqrt{2\pi}}\frac{1}{z}\exp\left\{-\frac{1}{2\sigma^2}(\ln z - \mu)^2\right\},$$

where μ and σ are respectively the mathematical expectation and standard deviation of the size of the reserves in individual pools.*

The view that the distribution of oil and gas pools by size of reserves is adequately described by a logarithmic function has been expressed by many authors (for a detailed bibliography see reference 6). In addition, the suitability of this distribution for description of empirical distributions of pools by size of reserves is statistically confirmed in the vast majority of oil-gas regions of the USSR containing a relatively large number of pools which have been discovered.

Regarding the time progression of the most important characteristics of the geological exploration process, we have made the following main assumptions.

1. The probability of discovering a pool when testing a promising tract is not constant and decreases as the resources of the region are increasingly developed. It is the practice to characterize the degree of development by the quantity $\rho = Q/R$, where Q is the total initial demonstrated reserves (reserves of pools that have been discovered with allowance for cumulative extraction up to the moment in question; and R is an estimate of the potential oil-gas content of the region. Thus the probability q of discovering a pool, which hereafter we will call the "success coefficient," is a decreasing function of ρ such that $\lim_{\rho \to 1} q[\rho] = 0$. It is easy to see that the simple relationship $q = q_0(1 - \rho)$, where q_0 is a constant, assumed in this paper, which can be determined by the least-squares method, satisfies all the conditions stated; in addition it is in agreement with available empirical data.

2. The average reserves of pools that are discovered are also not constant over the geological exploration process. Most homogeneous geological regions show a tendency for the larger pools to be discovered on average in the earlier stages of exploration of the region.

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* Here the mathematical expectation E(z) and standard deviation D(z) of the reserves in one pool are given in terms of μ and σ :

$$E(z) = \exp(\mu + \sigma^2/2), \quad D(z) = \exp(2\mu + \sigma^2)(\exp(\sigma^2) - 1).$$

Possible methods of empirically confirming this fact are described in reference 6, which in addition states the stronger hypothesis that the probability of discovering a pool is directly proportional to its size.

This paper assumes that the average reserves in the (n + 1)-th pool (from the beginning of exploration of the region) are proportional to the average sizes of the n fields already discovered and to the size of forecast reserves. In other words, we assume the correctness of the equation

$$z_{n+1} = k\frac{Q_n}{n}\frac{R-Q_n}{R},$$

where z_{n+1} is the average reserves of the (n + 1)-th field; Q_n is the total reserves of the n pools already discovered; $(R - Q_n)$ is the forecast reserve for the region, defined as the difference between the estimated oil-gas potential R of the region and the oil reserves Q_n in already-discovered pools; and k is a positive constant determined by the least-squares method.

This equation is not only in agreement with existing empirical data but also agrees well (when $0 < k \leq 1$) with the time behavior of average reserves of pools defined in the hypothesis of reference 6.

In addition to the above, we make several assumptions regarding the technical and economic indices of the geological exploration process and in particular the time trend of the average depth of prospecting and exploratory wells.

3. Exploration is conducted from the top down, i.e. the average depth of prospecting and exploration wells increases as the degree of exploration of the region increases.

4. The intensity of exploration of different horizons is proportional to the estimate of the potential reserves contained in them.

In checking the assumptions, deriving the main equations and evaluating the model parameters we used the following starting information: 1. potential resources of individual regions and their distribution over different horizons; 2. the time trend of number of promising tracts under exploration by year; 3. the time trend and distribution of the average number of wells required to test a promising tract as a function of test results; 4. a description of pools that have been discovered in the region, their reserves, their depths and the dates of discovery; 5. the time trend of the amount of prospecting and exploratory work, and the average depths of prospecting and exploratory wells by year; 6. the time trend of capital investments on prospecting and exploratory work by year, broken down by type of work.

Short Description of the Algorithm Used to Simulate the Geological Exploration Process

Let us briefly consider the simulation of the geological exploration process using the assumptions we have made (see diagram).

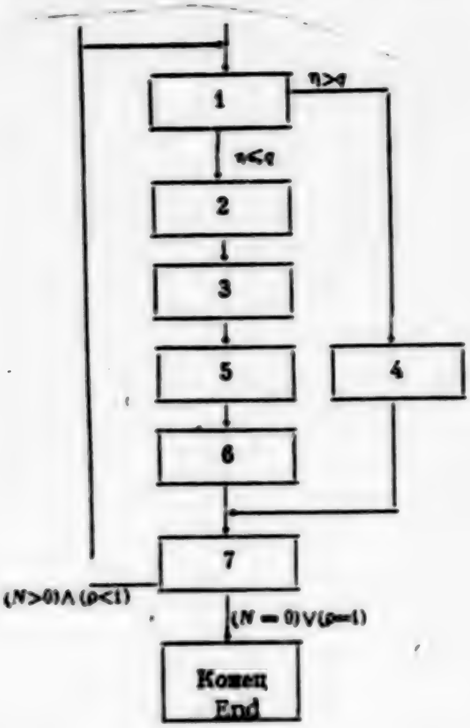

Diagram of principal section of the algorithm used to simulate the geological exploration process.

In block 1 the testing of the individual promising tract is modeled, i.e. the uniformly distributed pseudorandom variable $\eta \in (0, 1)$ is modeled and compared with the current value of the success coefficient q. If the tract proves unproductive ($\eta > q$), the algorithm branches to block 4, where the economic indicators associated with withdrawing a tract from exploration with negative results are calculated. Here the current value of the degree of development of the region's resources (ρ) is taken into account. If the "testing" of the tract in block 1 results in "discovery" of a pool ($\eta \leq q$), we branch to block 2.

Block 2 simulates the reserves of the pool that has been discovered in the form of a log-normal distribution of the pseudorandom quantity ξ with parameters corresponding to the current degree of development R of the region's resources. The reserves in the "discovered" pool are added to the total reserves of the region. Here we record each case in which the result thus obtained exceeds some preset level of total reserves.

In block 3, the depth range to which the pool "discovered" in the previous step belongs is found by using hypotheses 3 and 4. In block 5 the economic indices associated with the discovery and exploration of the field are calculated. In block 6 the new value for the degree of development of the region is calculated, taking account of the reserves of the pool "discovered" in blocks 1 and 2.

The success coefficient, the parameters of the formula for distribution of size of reserves and a number of technical and economic indices are then recalculated for the new value of ρ .

In block 7, the remaining tracts are considered. If they have not been used up ($N > 0$) and not all potential reserves have been developed ($\rho < 1$), the algorithm branches back to block 1 and the procedure is continued using the new data. But if the available tracts are used up (or $\rho = 1$), the simulation terminates.

Accuracy of the simulation is assured by multiple ($L = 1000$) iteration. Here the value $L = 1000$ gives a wide margin. For example, a decrease in L from 1000 to 500 leads to a difference in the results amounting to only tenths of a percent.

A table is drawn up from the output of the simulation model. Here $\tilde{z}_j$, $j = 1, \ldots, L$, is the specified level of total growth of reserves in the region; $\tilde{W}_i$, $i = 1, \ldots, M$, is the specified level of investment in exploration; f_{ij} is the probability of achieving an increase in reserves $z \geq \tilde{z}_j$ in capital investments on exploration amounting to $\tilde{W}_i$; the values of f_{ij} are determined on the basis of the frequency with which the specified total increase in reserves calculated in block 2 is exceeded; $E_i(z)$ and $\sigma_i^2(z)$ are respectively the mathematical expectation and the variance of the quantity of total reserves discovered with capital investments equal to $\tilde{W}_i$; and $E_j(W)$ and $\sigma_j^2(W)$ are the mathematical expectation and variance of the amount of capital investment producing a total increase $\tilde{z}_j$ in reserves.

Thus the rows of the table give the probability distribution of growth in reserves for a fixed amount of capital investment in exploration, while the columns give the probabilities of obtaining a given increase in reserves with different levels of capital investment. In addition, the output of the simulation is used to provide information on the expected distribution of future increases in reserves over pools of various size classes and over different depth intervals.

Data Base and Algorithms of the Regional Development Model

The methods of extracting the resource from each pool are characterized by the time trend of output levels, capital investments and production cost. Here capital investment and production cost are nonlinear functions of output levels. To eliminate or at least decrease the error resulting from representing these nonlinear quantities in a linear model, we propose the

Probability of Growth of Reserves as a Function of Size of Reserves and Capital Investment.

	Приросты запасов 1				**Математическое ожидание суммарных запасов** 2	**Среднеквадратическое отклонение суммарных запасов** 3
4 **Капитальные вложения в геологоразведку**	$\bar{z}_1$	$\bar{z}_2$	$\cdots$	$\bar{z}_l$	$E_W(z)$	$\sigma_W(z)$
$\tilde{W}_1$	f_{11}	f_{12}	$\cdots$	f_{1l}	$E_1(z)$	$\sigma_1(z)$
$\tilde{W}_2$	f_{21}	f_{22}	$\cdots$	f_{2l}	$E_2(z)$	$\sigma_2(z)$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$\tilde{W}_m$	f_{m1}	f_{m2}	$\cdots$	f_{ml}	$E_m(z)$	$\sigma_m(z)$
5 **Математическое ожидание капитальных вложений**						
$E_z(W)$	$E_1(W)$	$E_2(W)$	$\cdots$	$E_l(W)$		
6 **Среднеквадратическое отклонение капитальных вложений**						
$\sigma_z(W)$	$\sigma_1(W)$	$\sigma_2(W)$	$\cdots$	$\sigma_l(W)$		

Key: 1. Increase in reserves
2. Mathematical expectation of total reserves
3. Standard deviation of total reserves
4. Capital investment in geological exploration
5. Mathematical expectation of capital investment
6. Standard deviation of capital investment

following procedure for preparing the initial data on methods of extraction for the regional development model.

All reserves in the region in question are grouped by type of pool, distinguished by a number of attributes such as size of reserves in the pool, depth of burial, output of wells, type of pool (gas only, oil only, oil and gas, gas condensate and the like), presence of useful byproducts (sulfur, helium, condensate and the like), location and so on. These factors produce the main nonlinearity in the relationship of technical-economic indicators to output quantity of a pool.

The data on all existing plans (or temporary engineering plans) for development of pools in the region in question are presented in the form

$$(g_k^1,\ldots,g_k^{r_k}),\ (h_k^1,\ldots,h_k^{r_k}),\ (s_k^1,\ldots,s_k^{r_k}). \qquad (1)$$

Here $k \in K$, where $K = \cup K_i$, and K_i is the number of plans for developing pools of type i ($i = 1,\ldots,I$); g_k^t is the coefficient of utilization of the maximum capacity of a pool according to the k-th plan in the last year of the t-th five-year plan since the beginning of development; h_k^t is the amount of capital investment (associated with equipping the field according to the k-th plan during the t-th five-year plan) per unit of maximum capacity; s_k^t is the cost of extraction (averaged for the t-th five-year plan); and T_k is the number of years' operation of the field according to the plan. In this case, by maximum capacity we mean the level of constant output.

On the basis of this information and a statisitical approximation (e.g. the least-squares method), we can formulate a set J_i of possible development methods for a pool of type i:

$$\left.\begin{array}{c}(a_j^1,\ldots,a_j^{T_j})\\(f_j^1,\ldots,f_j^{T_j})\\c_j\end{array}\right\} \quad j \in J_i, \quad i = 1,\ldots,I, \tag{2}$$

where a_j^t and f_j^t are analogous in meaning to g_k^t and h_k^t, while c_j is the additional effective [privedennyy] expenditure (up to the last year of the initial five-year plan) associated with the equipping alone of the pool in question.

For a field which was under development before the beginning of the period in question (a set we will label K^0), we use equation (1) to determine the unit effective costs c_k (up to the last year of the initial five-year plan of the period in question) associated with continuation of development of the pool.

The effectiveness function for utilization of the resource is given in piecewise linear form by the indicators r_l^t, d_l^t, $t = 1,\ldots,T$, $\ell = 1,\ldots,L$, where r_ℓ^t is the unit effectiveness of utilizing the resource in the last year of the t-th five-year plan with an output level in the range

$$\left[\sum_{\tau=0}^{l-1} d_\tau^t, \ \sum_{\tau=0}^{l} d_\tau^t\right]; \qquad d_0^t = 0.$$

Here ℓ is the ordinal number of the interval on the piecewise linear function.

The function for conversion of predicted reserves to commercial reserves and the index of distribution of unit convertible resources by type are determined on the basis of simulation of geoolgical exploration work in the region. To specify the conversion function we set the total quantity of capital investment on geological exploration, the total quantity of convertible reserves and the probability of conversion.

From the specified parameters and the results from the table we calculate the values of p_m, d_m, $m = 1,\ldots,M$, where p_m is unit capital investmen
conversion of forecast reserves into commercial reserves with the total

quantity of commerical reserves falling within the interval

$$\left[\sum_{\tau=0}^{m-1} d_\tau, \sum_{\tau=0}^{m} d_\tau\right], \quad d_0 = 0.$$

Here m is the number of the interval in the piecewise linear function of investments on geological exploration.

The units of reserves convertible into the commerical category are distributed by type with reference to the coefficients $(\beta_{m1}, \cdots, \beta_{mI})$ in such a way that

$$\beta_{mi} \geq 0, \sum_{i=1}^{I} \beta_{mi} = 1, \; m = 1, \ldots, M.$$

When the time trend of capital investment $R_1^{\,t}$ allocated for development of pools and $R_2^{\,t}$ allocated for geological exploration in the territory in question are specified we can formulate the mathematical model for development of the region.

Mathematical Formulation of the Model

The nonnegative variables in the model are: x_k, the level of constant output of pool k under development; $x_{kj}^{\,t}$, the level of constant output of a known but not yet developed pool k K^1 using the j-th development method and beginning in the t-th five-year plan; $x_{ij}^{\,t}$, the level of constant output on fields of type i which will be discovered and developed during the period in question with development begun in the t-th five-year plan using the j-th method; $z_m^{\,t}$, the size of reserves converted to the commercial category in the t-th five-year plan in interval m of the piecewise linear function, $m = 1, \ldots, M$; and $y_1^{\,t}$, consumption of the resource extracted in the region in question in the last year of the t-th five-year plan in interval l of the effectiveness function.

The target function to be minimized, which consists of the difference between expenditures on extraction and exploration of the resource and the effectiveness of its utilization totaled for the entire period t in question, can be presented in the form

$$\sum_{k \in K^0} c_k x_k + \sum_{\substack{t=1 \\ k \in K^1, j \in J_k}}^{T} c_j(t) x_{kj}^{t} + \sum_{\substack{t=1, i=1 \\ j \in J_i}}^{T, I} c_j(t) x_{ij}^{t} +$$

$$+ \sum_{t=1, m=1}^{T, M} p_m(t-1) z_m^{t} - \sum_{t=1, l=1}^{T, L} r_l^{t}(t) y_l^{t}. \qquad (3)$$

Here a symbol of the type c(t) indicates that the indicator c is figured for the period between the last year of the t-th five-year plan and the last year of the first five-year plan of the period in question [1 T].

The balance of extraction and consumption of the resource is

$$\sum_{k\in K^0} g_k^{t+t_k^0} x_k + \sum_{\substack{\tau=1\\ k\in K^1,\ j\in J_i}}^{t_0} a_j^{\tau} x_{kj}^{t-\tau+1} + \sum_{\substack{i=1,\ \tau=1\\ j\in J_i}}^{I,\ t_0} a_j^{\tau} x_{ij}^{t-\tau+1} - \sum_{l=1}^{L} y_l^t > 0,\ t=1,\dots,T, \qquad (4)$$

where t_k^0 is the number of five-year plans during which the existing wells have been under development before the beginning of the perio in question, $t_0 = \min\{T_j,\ t\}$. To describe the constraints on the level of constant output of pools, we introduce the quantities α_k and α_j, which are equal to the time during which the pool is to be worked using the method at maximum capacity only. Let B_k be the size of the reserves in the k-th field. Then the constraints for existing and known wells and those to be discovered are

$$\alpha_k x_k \leq B_k,\quad k\in K^0, \qquad (5)$$

$$\sum_{t=1,\ j\in J_i}^{T} \alpha_j x_{kj}^t \leqslant B_k,\quad k\in K^1, \qquad (6)$$

$$\sum_{j\in J_i} \alpha_j x_{ij}^t - \sum_{m=1}^{M} \beta_{mi} z_m^t = 0,\ i=1,\dots,I,\ t=2,\dots,T. \qquad (7)$$

The constraints on capital investment in extraction and exploration of the reserves are

$$\sum_{k\in K} h^{t+t_k^0} x_k + \sum_{\tau=1}^{t_0} f_j^{\tau} x_{kj}^{t-\tau+1} + \sum_{\substack{i=1,\ \tau=1\\ j\in J_i}}^{I,\ t_0} f_j^{\tau} x_{ij}^{t-\tau+1} \leqslant R_1^t,\quad t=1,\dots,T, \qquad (8)$$

$$\sum_{m=1}^{M} p_m z_m^{t+1} \leqslant R_2^t,\quad t=1,\dots,T-1. \qquad (9)$$

The final conditions in the regional development model are constraints governing the "degrees" of the piecewise linear functions for expenditures on conversion of forecast reserves into commercial ones and the time trend of effectiveness of utilization of the resources extracted in the region in question

$$\sum_{t=1}^{T} z_m^t \leqslant d_m,\ m=1,\dots,M, \qquad (10)$$

$$y_l^t \leq d_l^t,\ l=1,\dots,L,\ t=1,\dots,T. \qquad (11)$$

To organize the data base, formulate the model defined by (3)-(11), solve it and analyse the results, the SEI [Siberian Energy Institute], Siberian Department, USSR Academy of Sciences has developed a program package making it possible to carry out the abovementioned stages in a nearly interactive mode, which makes it much simpler to carry out experimental calculations.

In order to test the workability of this method of optimizing the regional extraction plan and also to provide information for the model for development of the fuel and energy complex [1], we calculated the long-term gas extraction levels for the northern areas of Tyumenskaya Oblast (SRTO). The calculations based on the simulation of geological exploration work made it possible to determine the relationship of unit costs of exploration and the size of forecast reserves. In terms of size of reserves, their depth and their position, we distinguished five types of fields, and the breakdown of forecast reserves (by type) was determined on the basis of the geological exploration simulation model. The complementation cost function for gas in Northern Tyumen' was formulated from variation calculations using the model for optimization of the development of the fuel and energy complex for the last years of the five-year plans in the period in question.

For all types of pools, the development methods were formulated in the form of equation (2) on the basis of known plans and temporary engineering plans. The resulting effective expenditures per unit of maximum capacity were varied according to the type of pool and the development time for the method in question. In the given case, the model defined by (3)-(11) contained 271 equations and 1,238 variables. Calculations were made for a relatively high probability of conversion of forecast reserves into industrial ones (equal to 0.9).

Initially we investigated the possibility of extracting gas in the absence of constraints on capital investment in extraction and exploration and also with unlimited demand for gas extracted in Northern Tyumen'. The calculation results gave the curve for optimum output levels and economically justifiable complementation costs for gas in the regions in question. Here the complementation cost levels increased over time as a result of the exhaustion of reserves and the beginning of development of pools with worse economic characteristics.

1. The constraints that made themselves most strongly felt were those on capital investment on extraction of the resource. Making these constraints more stringent not only changes the strategy for putting known pools into development and the time trend of extraction indicators for the resource, but also increases the total level and changes the time trend of economically justifiable complementation costs.

2. The effect of increasing the total complementation cost level for gas in Northern Tyumen' manifests itself by intensifying the methods of gas extraction (changeover to more expensive but quicker methods) and in a stepped-up pace of conversion of forecast reserves to commercial ones.

3. A switch to a lower (or higher) probability of conversion of reserves into the commercial category has practically no effect on the time trend of the gas extraction indicators for the first five-year plan of the period in question.

Joint consideration of the models for optimization of the fuel and energy complex and of the region indicated that the latter was essentially workable, but at the same time it enabled us to find weaknesses in certain assumptions. In particular, in formulating expenditures for implementation of various methods for developing pools we took account, as mentioned above, only of expenditures on equipping the field. This led to intensive development of the group of pools requiring rather low expenditures for equipment, but whose development was possible only by creating a certain infrastructure. This fact clearly led to a certain exaggeration of the output level. At present this model is being restructured to introduce new components characterizing the creation of an infrastructure in the region.

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FUELS AND RELATED EQUIPMENT

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SPECIFIC WAYS TO IMPROVE GAS WELL CONSTRUCTION ENUMERATED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 pp 6-9

[Article by M. I. Agapchev, deputy minister of the gas industry: "Ways To Reduce Well Construction Time"]

[Text] The efficiency of capital investment in drilling is largely determined by increasing the rate of well construction, technical equipment available for drilling work, introducing highly productive equipment and advanced technology, and improving the organization of primary and auxiliary well drilling processes. The impact of these factors must not only compensate for more complex well drilling conditions, but even promote an improvement in the economics of drilling work.

In the gas industry the drilling branch is third for capital-intensiveness after gas transportation and industrial construction. Drilling accounts for the largest part, about 70 percent, of the structure of capital investment by this subsector. The remaining expenditures are spread among preparatory and construction-installation jobs, well testing, and field geophysics.

Implementation of the decisions of the CPSU Central Committee and USSR Council of Ministers decree entitled "Improving Planning and Strengthening the Influence of the Economic Mechanism on Raising Production Efficiency, Work Quality" will make it possible, on the basis of improvement in the management of the well construction process, to raise the efficiency of capital investment in drilling and cut the time required to drill wells and turn them over for exploitation.

Evaluation of the predicted technical-economic indexes of drilling for the period until 1980 with due regard for the increase in depth and growing complexity of well sinking conditions reveals, where other conditions are equal, a trend toward greater cost of drilling work for both exploratory and operations drilling (7.0 and 17.2 percent respectively) and lengthening of the well construction cycle (4.5 and

5.3 percent respectively). Therefore, reducing well construction time is becoming a paramount challenge for the drilling enterprises of the sector.

The gas industry has a fair amount of experience with highly organized drilling work. For example, the drilling enterprises of the Ukrainian SSR Main Administration of the Gas Industry, which have been recognized as the best in the Ministry system, are concentrated in the Ukrburgaz [Ukrainian Gas Drilling] Production Association. Since 1973 the association has systematically overfulfilled plan assignments, guaranteeing high technical-economic indexes of drilling. Productive drilling time has risen from 63.4 percent in 1973 to 85.4 percent in 1978. Schedule speed has increased from 457 m/st [possibly standard meters] per month in 1973 to 564 m/st per month in 1978. The plan for completion of well construction is regularly overfulfilled.

At the same time, there are significant reserves in the organization of drilling work at deposits in the principal gas regions of the country whose utilization would permit a striking improvement in the technical-economic indexes of well drilling. Inadequate preparation for drilling leads to large amounts of downtime, violations of production procedures, complications, low drilling speed, and inefficient use of materials and equipment.

The volume of drilling work at many associations has stabilized in recent years. This creates favorable conditions for improving technical-economic indexes, consistent fulfillment of plan assignments, and raising the quality and efficiency of drilling work. However, for various reasons some drilling enterprises are permitting large, unproductive losses of working time, which increases well construction time.

Analysis of figures on the duration of construction of wells by associations for a number of years showed that significant expenditures of time for installation, drilling, and development are constant.

In 1978 the average length of well construction for the Ministry of the Gas Industry was 142 days for operations drilling and 383 days for exploratory drilling. The causes of the length of particular stages of well construction in various regions of the country differ, so the search for ways to cut time must be conducted separately for each association.

The Tyumengazprom [Tyumen' Gas Indus[illegible] All-Union Production Association carries out its drilling with [illegible] of the Polar, Urengoy, and Vyngapur EGB's [expansion unknow[illegible] average length of the entire cycle of well construction is 49.5 [illegible], of which installation takes 7.8 days, development 24.6 days, and drilling 17.1 days.

All derrick installation brigades overfulfill their plan assignments for number of rigs installed each year and the cost of construction per rig drops year after year. Use of the battery-group method of constructing clustered wells and having preparatory jobs done by specialized teams promote this efficiency.

However, the calendar time of installation (181.6 hours) exceeds the calculated time for installation work. The calendar time of derrick installation brigades can be used more fully by increasing the number of working shifts.

At the present time in the association well development takes as long as installation and drilling together. Unsatisfactory organization of this type of work is indicated by the index of use of calendar development time in 1978, when productive time was just 28.2 percent, waiting for development was 61.3 percent, and unproductive time was 10.5 percent.

The drilling brigades of the association do only the initial jobs of well development (framing the head, perforating and lowering the pumping-compressor pipe). Then the drilling rig is dismantled and further work is done by a special brigade.

When jobs are organized in this way time losses linked to waiting for dismantling of the drilling rig and the absence of the rig or the brigade were 25.6 percent of calendar time for well development at the Tyumengazprom Association.

It is plain that having drilling brigades do well development jobs is a reserve that could significantly speed up this process.

The existence of significant reserves for reducing well drilling time in the association is confirmed by the results of sinking production test wells. For example, the schedule speed in drilling well No 180 at the Vyngapur deposit (brigade leader R. T. Partibayev) was 3,250 m/st per month where the average rate achieved at the deposit in 1978 was 2,371. The scheduled speed in drilling well No 234 at the Urengoy deposit (brigade leader N. D. Pereshchenko) was 2,755 m/st per month, 938 m/st per month higher than the average schedule speed for this deposit.

The Turkmengazprom All-Union Production Association does well construction work with the personnel of the Achakskiy, East Turkmen, Mary, and Chardzhou drilling administrations. The association's average time of construction is 246.3 days for operations wells and 660.9 days for exploratory wells.

Drilling accounts for the largest part of the work cycle in construction of operations wells (177.6 days). Installation and development take 18.3 and 50.4 days respectively.

The ratio of time expenditures by types of jobs is somewhat different in exploratory drilling, where the total length of well construction time is 660.9 days. The times required for installation, drilling, and development are 46.6, 305, and 309.3 days respectively.

Development of one exploratory well takes almost six times longer than development of an operations well. The higher labor-intensiveness of work on the development of exploratory wells results from the existence of a large number of sites on the profile and the large volume of research work. Moreover, having development brigades work in one shift greatly increases the construction time for exploratory wells. Productive time in development of exploratory wells at Turkmengazprom is 32.9 percent while time waiting for development is 19.1 percent and downtime is 41.8 percent.

Unsatisfactory organization of work to develop exploratory wells at the association is often explained by the lack of norms for development work. The formulation and introduction of norms is one of the key reserves for reducing the construction time of exploratory wells.

The Turkmengazprom Association has some reserves for reducing well construction time by speeding up installation, but the greatest reserve is reducing the time used for drilling and well development.

Useful experience with sinking industrial test wells illustrates the possibility of increasing drilling speeds. During the current year the drilling of industrial test wells with planned schedule speeds of 950 m/st per month (Severnyy Balkui) and 1,000 m/st per month (Kirpichli) will more than double the average rate for the deposits.

The length of well construction at the Ukrgazprom [Ukrainian Gas Industry] Association is 190.3 days for gas exploratory drilling (27.6 days installation, 123.3 days drilling, and 39.4 days development) and 607 days for exploratory drilling (81.3 days installation, 419.6 days drilling, and 106.1 days development).

Most of the wells are developed by drilling brigades working from drilling rigs. This is the reason for the high proportion of productive time in well development at Ukrgazprom (57.6 percent in operations drilling compared to the average index of 29.8 percent for the Ministry of the Gas Industry).

Nonetheless, to step up work on well development it is essential to establish norms and improve material-technical supply to drilling sites.

The schedule speed of drilling gas wells in the republic rose from 520 to 604 m/st per month in operations drilling with a decrease in well depth from 2,493 to 2,293 meters; for exploratory drilling it went from 247 to 339 m/st per month while depths decreased from 4,704 to 3,947 meters.

Reserves for increasing speed revealed by the experimental sinking of industrial test wells at the Krestishchenskoye deposit testify to the possibility of a further increase in the efficiency of capital investment in drilling.

The total length of well construction time for operations drilling at the Soyuzuzbekgazprom [USSR-Uzbek Gas Industry] All-Union Production Association is 276.5 days.(39.5 days installation, 180.7 drilling, and 56.3 development); in exploratory drilling the total is 463.5 days (25.0 installation, 182.3 drilling, and 256.2 well development).

The level of organization of derrick installation work is roughly the same as at other associations of the sector. The shift factor is not used adequately for equipment, the number of personnel is low, and there is not adequate technical equipment for derrick installation jobs.

Development work takes a large part of well building time: 20.4 percent in operations drilling and 55.3 percent of total well construction time in exploratory drilling. Work in this stage of well construction is done by special development brigades. Because of poor material-technical support and weak job organization productive time in development work is just 10.6 percent, while 66.1 percent of the time is spent waiting for the beginning of development work and 21.5 percent is downtime.

Changing to well development with drilling brigades will eliminate time expenditures waiting for development and make it possible to reduce the length of the well construction cycle in operations and exploratory drilling by 80 and 198 days respectively.

The Komigazprom [Komi ASSR Gas Industry] All-Union Production Association constructs the deepest wells of the Ministry of the Gas Industry under extremely difficult natural and climatic conditions. This is why it has the greatest construction time in the ministry for operations wells (569.5 days) and exploratory wells (879.3 days). For the same reasons the length of development work on exploratory wells is unusually high (98.8 days).

The success of leading drilling brigades in the Komigazprom Association testifies to the possibility of increasing the schedule speed of drilling for operations and exploratory wells.

Analysis of data on length of jobs related to installation, drilling, and development at the Orenburggazprom [Orenburg Gas Industry], Kuban'morneftegazprom [Kuban' Offshore Petroleum Gas Industry], Stavropol'[Gas Industry], Noril'skgazprom [Noril'sk Gas Industry], Yakutgazprom [Yakut ASSR Gas Industry], and Soyuzburgaz [USSR Gas Drilling] associations revealed shortcomings characteristic of the associations considered above.

An increase in the efficiency of capital investment in drilling and reduction of well construction time for the sector as a whole can be achieved by a combination of the following scientific-technical and organizational steps:

1. incorporation of drilling rigs that can be installed anywhere, increase in the energy-availability of winches and drilling pumps, expanding the possibility of hauling large modules of drilling rigs on special heavy trucks;
2. insuring delivery by appropriate plans of essential modules for equipment in place of modules manufactured at the drilling enterprises and repair plants of the associations;
3. increase in drilling volume by using highly efficient rock-breaking tools;
4. use of high-strength drilling pipe;
5. refinement of schedules and use of most efficient drilling techniques;
6. improvement in degree of removal of drilled rock from flushing liquid by improving circulation systems and introducing new equipment;
7. preparation of flushing liquid based on powdered materials using special BPR-70 units to mix a clay solution;
8. rise in labor productivity in drilling through mechanization and automation of production processes;
9. layer testing and well development by the personnel of the drilling brigade without dismantling the drilling rig;
10. organization of well development work in three shifts;
11. formulation of norms for well development by work areas;
12. organization of installation of drilling rigs by sliding shift schedule with an increase in the number of shifts;

13. broader use of experience from sinking industrial test wells.

These measures, worked out at the central administrative apparatus of the Ministry of the Gas Industry with the participation of drilling specialists, heads of enterprises and scientific research organizations, and representatives from associated sectors, now constitute a concrete program to improve technical-economic indexes in drilling.

Implementation of this program is aimed at swiftly carrying out the decisions of the party and government in the field of development of the gas industry and bolstering the national economy.

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NEW SYSTEM AIMED AT BETTER PLANNING IN OIL, GAS INDUSTRY

Moscow STROITEL'STVO TRUBOPROVODOV in Russian No 10, Oct 79 pp 1-3

[Article: "Preparation for Transition to a New System of Economic Work"]

[Text] Socialist competition for early completion of the Tenth Five-Year Plan as a whole is broadening in the organizations and enterprises of the Ministry of Construction of Oil and Gas Industry Enterprises (Minneftegazstroy). The front-ranking collectives are greeting USSR Constitution Day with successful fulfillment of the quotas for 1979. The builders of oil and gas industry enterprises are constantly increasing the rates of work, they are revealing the reserves of production and putting them into operation.

In the sector much attention is being given to improvement of economic activity, planning and management. A complex of measures is being implemented regarding fulfillment of the CPSU Central Committee resolution "On Further Improvement of the Economic Mechanism and the Tasks of Party and State Agencies" and the resolution of the CPSU Central Committee and the USSR Council of Ministers "On Improving the Planning and Increasing the Effect of the Economic Mechanism on Raising the Effectiveness of Production and the Quality of Work."

The decisions regarding improvement of planning and operation are directed at a further rise in their level, bringing them into accord with the demands of developed socialism, at a significant increase in the effectiveness of public production, acceleration of scientific and technical progresss and growth in labor productivity, and improvement of product quality.

Guided by the resolutions of the party and the government about improving planning and the economic mechanism, the collectives of enterprises and organizations of Minneftegazstroy have widely unfolded preparations for a transition to the new system of economic work.

The new system of economic work foresees first of all a rise in the level of planning.

In the sector, beginning with the 11th Five-Year Plan, planning and evaluation of economic activity will be carried out according to the indicators of putting production capacities and projects into operation, commodity construction output, growth in labor productivity and profit.

The success of the work according to the new system, and its foundation is being laid even now, will also depend on the quality of preparation. Therefore it is required to implement the outlined measures timely and precisely, to carry out absolutely the corresponding orders and decrees.

A complex of measures aimed at further improvement of planning and the economic mechanism is being implemented in the sector in accordance with a special order for the ministry.

Based on the resolution of the CPSU Central Committee and the USSR Council of Ministers, "On Improvement of Planning and Strengthening the Action of the Economic Mechanism on Raising the Effectiveness of Production and the Quality of Work," methodical instructions should be prepared regarding development of the five-year and annual plans of economic and social development of the Minneftegazstroy for 1981-1985. Taking into account the new requirements for compilation of the plans it is necessary to change the "Temporary Regulation on the Procedure for Plan Development in Minneftegazstroy" (1976).

Beginning with 1981 in the five-year plans for main administrations and associations of Minneftegazstroy the following indicators for construction output will be approved (with distribution of the assignments by years):

Putting production capacities and projects into operation (including the growth in capacities owing to technical retooling and remodeling of operating enterprises). This indicator will be set also for organizations which assemble basic technological and power equipment according to contracts;

The toal (with distribution according to clients) and in-house performed volume of commodity construction output (cost of construction and installation operations for enterprises turned over to the client, phases, underway complexes, and facilities prepared for producing a product or rendering of services);

Growth in labor productivity;

Limit of the number of workers and employees;

Total wage fund;

Profit (for some organizations, reduction in the prime cost of construction and installation operations);

Assignments for incorporation of new technology;

The volume of supplies of materials, machinery, mechanisms and other material and technical resources necessary for fulfillment of the plan.

In 1979-1980 a standard estimate base should be drawn up for targets in the oil and gas industry for the gradual transition in the 11th Five-Year Plan to planning labor productivity and wages in construction-installation organizations according to net output (standard) or according to another indicator which more accurately reflects changes in labor outlays.

Organizations of the ministry are preparing a number of standards and methods documents. Thus, being compiled in coordination with the main clients is a regulation on the definition of commodity output in the construction of enterprises of the oil and gas industry.

Methodical instructions regarding planning, financing and giving loans to construction organizations are being worked out with application to the conditions of settlements for commodity construction output. Also being developed is a regulation on the formation and distribution of the profit of construction organizations and industrial enterprises. It is planned to prepare methodical instructions on planning labor productivity and the wage fund in construction-installation organizations according to net output (standard) or another indicator, which would reflect more accurately the changes in labor outlays.

In 1980 it is foreseen to begin introducing planning and settlements according to commodity construction output in the trusts.

In the make-up of the five year plans, lists (with the basic technico-economic indicators) of enterprises and buildings, the construction of which will be started, and also lists of operating enterprises targeted for renovation and expansion will be worked out and approved in order to insure continuity of action of the plans for capital construction and to increase the responsibility for putting production capacities and projects into operation on time. Title lists of projects for the whole period of construction with distribution of the assignments by years should be compiled on the basis of the indicated lists of construction projects, limits of capital investments and construction-installation operations, plans, estimates and norms of the duration of building.

Approved in the annual plans are the same indicators as in the five-year plans, with specification of the assignments for the corresponding years, as well as payments to the state budget and allocations from it.

When working out the plans for economic and social development it is necessary to solve the problems comprehensively, concentrating forces and resources on fulfillment of the major programs of the sector. It is necessary to insure acceleration of the introduction of scientific and technical developments, aimed at increasing the rates of growth of labor productivity and product quality. It is also necessary to provide for rational utilization of productive capital, physical, labor and financial resources, stepping up the regime of economy and eliminating losses. The plans should contribute to an increase in the effectiveness of capital investments, to formation of physical and financial reserves necessary for proportional and balanced development of the sector's economy.

In accordance with the resolution of the CPSU Central Committee and the USSR Council of Ministers "On Improvement of Planning and Increasing the Effect of the Economic Mechanism on Increasing the Effectiveness of Production and the Quality of Work," to be worked out in the plans for economic and social development of the sector are summary sections for the whole complex of measures in the field of social development, including measures for improvement of working conditions, improvement of the skills and occupational mastery of workers and the general educational and cultural level of workers, improvement of housing and cultural and domestic conditions, medical services and so on. All these measures should be coordinated with the assignments for development of production, for capital cnnstruction and for increasing their effectiveness.

Plans for raising the technical level of the sector, plans of projects for nature and environmental protection, and plans for utilization of secondary materials and other resources are being worked out and approved in the make-up of the five-year plans in order to given comprehensive consideration to scientific and technical advances in the plans for economic and social development. Provided in the plans for raising the technical level are programs for solution of sectorial scientific and technical problems and for complex utilization of natural resources, as well as measures for creation, development and incorporation of new high-quality items and materials, machines and equipment, and progressive technology, and for improvement of production and raising the quality of output.

Proposals are being prepared in the sector for the compilation and approval by USSR Gosplan of a list of target complex scientific-technical, economic and social programs for the 11th Five-Year Plan, in the realization of which the Minneftegazstroy will participate. Among these programs is the development of the oil and gas complex of Western Siberia.

The Main Planning and Economic Administration (GlavPEU) and the Main Administration of Capital Construction (GUKS) of the Ministry of Construction of Oil and Gas Industry Enterprises have been instructed opportunely (in the course of a month after receiving the data from USSR Gosplan) to inform the main administrations and associations of the control figures for the basic indicators and economic norms for the coming five-year plan for the long-range planning of the sector's economic and social development.

It is the task of the main administrations and associations, guided by the control figures, to work out the drafts of the five-year plans (with a breakdown of assignments by years). The nomenclature (assortment) of output for conclusion of economic contracts should be determined beforehand jointly with the sales organizations.

On the basis of the control figures and drafts of five-year plans submitted by the main administrations and associations, GlavPEU and GUKS compile drafts of the five-year plans (with a breakdown of the assignments by years) respectively by sectors and send them to USSR Gosplan.

The transition to the new methods of economic work provides for, in addition to a rise in the level of planning, the implementation of measures for speeding up the putting of production capacities and projects into operation, and for a rise in the effectiveness of capital investments.

Such measures are being developed in the system of the Minneftegazstroy. It is planned to reduce sharply the number of newly begun construction projects in order to bring the volume of unfinished construction up to the established norms in the near future. In regarding the new construction and operating production as a unified whole, it follows to direct capital investments only for the planned growth in the volume of industrial output. The necessary means and resources will be allocated first of all to the renovation and technical retooling of operating enterprises.

The plan balances and calculations of utilization of available production capacities and fixed capital should be worked out in the make-up of the plan for 1981-1985. It is necessary to include in it also the summary plans of renovation and technical retooling of operating enterprises, including at the expense of the production development fund, having presented calculations of the demands for capital investments and equipment in order to produce the planned volume of output. When submitting the planning assignments for the five-year plan regarding in-house capital construction to the main administrations, administrations and associations it is necessary to leave a reserve of capital investments, construction and installation and contracting jobs in the amount of up to 5 percent of their total ceiling with the corresponding physical and financial resources.

In order to increase further the effectiveness of construction of projects in the oil and gas industry it is envisaged in 1981 to complete the introduction of settlements with the clients for enterprises that are completely finished and turned over for operation, for underway complexes, phases and projects prepared for the production of output and the rendering of services. according to the estimated cost of commodity construction output. It should be kept in mind that with the transition to this procedure for settlements, the giving of advances by the clients to the contracting organizations for the outlays for unfinished construction and installation operations will be stopped.

Reduction of the times required for putting erected projects into operation will, undoubtedly, be furthered also by the strict observance in the sector of the procedure providing for including in the plans for contracting jobs (beginning with 1981) only those construction projects for which as of 1 July of the year preceding the planned one the planning and estimate documents, as well as the working drafts for the annual volume of operations, have been submitted.

Improvement of management is an important direction for further increasing the effectiveness of the consrruction industry. In November of this year it is planned to complete the draft of a general plan for management of the sector. This draft will be reviewed in the Scientific and Technical Council of the Ministry of Construction of Oil and Gas Industry Enterprises. It is proposed to implement the transition to a two- and three-unit system of management in 1979-1981.

In the preparations for the transition to a new system of economic work a large part is set aside for measures aimed at development of cost accounting, at increasing the role of economic levers and incentives.

Speeding up the transition in pipeline construction to the brigade contract is an urgent task. In 1978 only 17.6 percent of the toal volume of construction and installation operations was performed by this method. It is necessary more fully to utilize the cost-accounting methods of organizing the competition of builder collectives.

The Administration of Organization of Labor and Wages of the ministry, jointly with the Center for Scientific Organization of Labor of "Neftegazstroytrud" have been instructed to prepare proposals before January 1980 regarding the extensive development of the brigade form of organization and stimulation of labor in the sector, keeping in mind that such a form should become the basic form in the 11th Five-Year Plan.

In 1979 it is envisaged to work out a target program of gradual transition to the construction of "turnkey" facilities for the oil and gas industry, and particularly oil product pipelines. Cost accounting should also further the acceleration of scientific and technical progress.

It is noted in the resolution of the CPSU Central Committee and the USSR Council of Ministers "On Improvement of Planning and Increasing the Effect of the Economic Mechanism on Raising the Effectiveness of Production and the Quality of Work" that it is required in 1980 to complete the conversion of scientific-research, planning and design and technological subdivisions to the cost-accounting system of operations for the creation, development and introduction of new technology on the basis of schedule-orders (contracts). Awards will be given for creation and introduction of new technology depending on the total economic benefit actually obtained in the national economy from the utilization of the advances of science and technology.

The Main Technical Administration of Minneftegazstroy has been instructed to develop and implement measures for the conversion of scientific research, planning and design and technological organizationsto the system of settlements for work that is fully completed and accepted by the client (instead of step-by-step payment for jobs).

Measures are also being taken in the sector to increase the stimulating role of bonus systems in raising the effectiveness of production and the quality of work. After the new normative documents come out the rules now in effect about awarding bonuses will be brought into correspondence with the procedure for formation of material incentive funds and the criteria for evaluating the performance of production associations (enterprises) and organizations, provided by the decisions of the party and the government regarding improvement of planning and the economic mechanism. It is intended that the bonuses should given in relation to the labor contribution of the collective and each worker.

A successful transition to the new system of economic work demands comprehensive study of it and, consequently, special training of the managerial staff and representatives of the economic services of the sector's enterprises and organizations. It is planned to set up the appropriate groups in the Institute for Advanced Training of Managers and Specialists of Minneftegazstroy. Short-term courses will operate directly in the organizations and at the enterprises. The training of workers on the ministry staff is envisaged. The necessary training programs are being compiled. Seminars on questions of improving the economic mechanism will be held for managers and specialists in construction and installation trusts and industrial enterprises.

In this way, the collectives of the Ministry of Construction of Oil and Gas Industry Enterprises, taking measures for an improvement in planning, for raising the effectiveness of capital investments, and increasing the role of cost accounting, of economic levers and incentives, will carry out all-round preparation for the transition to the new methods of economic activity envisaged by the decisions of the party and the government. After learning these methods, the subdivisions of the sector will be able to achieve new successes in the further growth in the effectiveness and improvement of the quality of construction.

In marking the second anniversary since the adoption of the new USSR Constitution, the collectives of the Minneftegazstroy will do everything possible in order to make a still more ponderable contribution to the development of the country's fuel and power complex.

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FUELS AND RELATED EQUIPMENT

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NEW LARGE-CAPACITY GAS SEPARATION UNIT TESTED, DESCRIBED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 pp 21-22

[Article by V. M. Kiselev, A. A. Tripol'skiy, and V. T. Gradyuk, UkrNIIgaz and Kharkov Gas Industry Administration: "High-Productivity Gas Separator with Axial Swirler"]

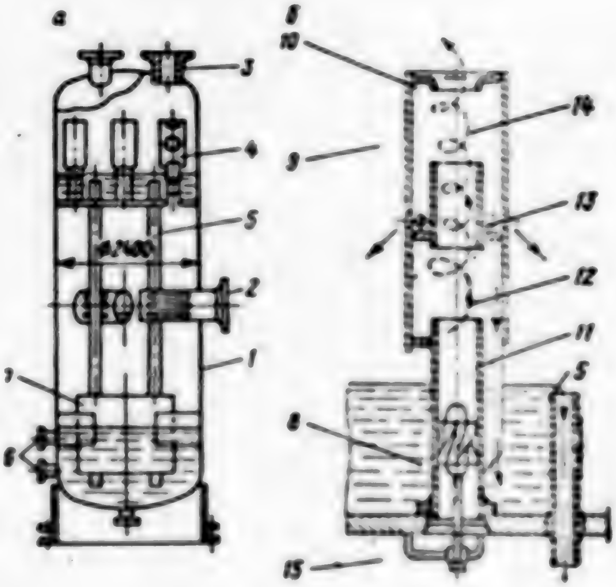
> [Text] The new gas separator combines high productivity with universal applications for a broad range of loads. It removes liquids and mechanical impurities from gas very reliably, at the same time capturing the gas condensate and reducing losses of diethyleneglycol, an expensive reagent.

At the present time the low-temperature separation method is used to prepare gas at most gas condensate deposits. This method is accomplished in two stages, with the introduction and regeneration of diethyleneglycol. Experience shows that, owing to flaws in the separators used, the two-stage system of gas preparations does not insure gas of the necessary qualities.

To improve the quality of gas separation UkrNIIgaz [Ukrainian Scientific Research Institute of Gas] and the Kharkov Gas Industry Administration have developed a gas preparation technology that involves the use of installed modules from YuzhNIIgiprogaz [Southern Scientific Research and Planning Institute of the Gas Industry] with two-stage separation by distinct technological lines and a large-capacity gas separator for the entire comprehensive gas preparation complex in the third stage of separation.

The new GSV-2400-64 gas separator with axial swirlers was manufactured by the Volgogradneftmash [Volgograd Petroleum Machinery] Production Association from drawings done by UkrNIIgaz. The design of the separator and its working principle are shown in the figure below.

Figure. Cross-Section (a) and Separation Element (b) of the GSV-2400-64 Gas Separator.



Key:
(1) Housing of Separator;
(2) Gas Inlet;
(3) Gas Outlet;
(4) Separation Element;
(5) Discharge Pipe;
(6) Accumulated Liquid Outlet;
(7) Divider;
(8) Immobile Axial Swirler;
(9) Separation Chamber;
(10) Exhaust Opening;
(11) Fluid Outlet from Separation Element;
(12) First Separation Zone;
(13) Holes for Discharge of Material Removed;
(14) Second Separation Zone;
(15) Cross-Piece.

The gas separator consists of housing 1, which is a vessel 2,400 millimeters in diameter at a working pressure of 64 kilogram-force per square centimeter. The gas is let in through three jets 2 (400 millimeters in diameter) arranged in the middle part of the housing at an angle of 120 degrees to one another. The jets have slit openings for even distribution of the gas. The cleaned gas is removed through three connecting pipes 3 (400 millimeters in diameter) located in the upper part of the unit. The separation elements 4 are set on a horizontal plate inside the apparatus. The separated fluid is removed from the plate through discharge pipe 5 and from the apparatus through connecting pipes 6. Vertical plate 7 operates as a "tranquilizing" divider to prevent wave formation and denudation of the hydroseal. Immobile axial swirler 8 turns the gas-liquid stream being separated and the liquid is removed in separation chamber 9 through the action of centrifugal force. The cleaned gas in the form of a swirling stream escapes from the separation element through exhaust diaphragm opening 10. Liquid from the separation element runs out through pipe 11. The largest amount of liquid is removed in first zone of separation 12. The liquid captured in the second zone of separation 14 flows through hole 13 on to a plate. The separation elements are secured to the plate by means of plate. The separation elements are secured to the plate by means of cross-piece 15.

Technical Specifications of GSV-2400-64 Gas Separator.

Gas Productivity at Pressure of 55 kgf/cm^2, millions of m^3/day:	
Maximum	up to 20
Rated	15
Minimum	8
Working Pressure, kgf/cm^2	up to 64
Working Temperature, degrees C	up to -30
Liquid Loading for Test, m^3/hr	up to 70
Condensate Factor for Maximum Gas Loading, cm^3/m^3	up to 135
Number of Separation Elements	290
Weight, tons	40

The primary objective in development of the new device was to build a gas separator of large unit capacity (within the dimensions of the existing vessels) with a universal loading range to insure separation of the entire stream of cold gas handled at one comprehensive gas separation unit.

The new gas separator was tested at UKPG-2 of the Krestishchenskoye deposit, where it was connected up as the concluding unit of the third stage of separation. The gas separator receives the entire stream of cold gas after the second-stage separators, consisting of 14 modules, (designed by YuzhNIIgiprogaz) with a productivity of 1 million cubic meters a day apiece and five modules (designed by Giprogaz [State All-Union Institute for the Design of Gas Pipelines and Gas Industry Enterprises]) with capacities of 500,000 cubic meters a day apiece. The test conditions involve separation pressure of 52-54 kilogram-force per square centimeter, 2-3 grams of drop-type condensate in the gas, and a gas density of 0.788 kilograms per cubic meter under standard conditions. Table 1 presents the results of industrial testing of the gas separator.

It follows from the figures in Table 1 that the gas separator has low hydraulic resistance and gives a difference of about 2-2.4 degrees C between the dew point and separation temperature as compared to 7-8 degrees C for standard devices.

Table 1. Results of Experimental Industrial Tests of GSV-2400-64 Gas Separator with Axial Swirlers

Expenditure of Gas, millions of m^3/day	Pressure Drop on Separator Plate, mm water col	Separation Temperature, °C	Dew Point for Hydrocarbons, °C	Difference of Dew Point and Separation Temperature, °C	Separation Efficiency, %	Quantity of Stable Condensate Captured, g/m^3	Quantity of Diethyleneglycol, liters per day
7,8	—	—1,0	1,0	2,0	—	—	—
15,2	69	2,0	4,4	2,4	93,1	1,85	130
16,8	90	—12,0	—7,5	4,5	89,1	2,10	138
17,3	98	—14,0	—7,3	6,7	84,0	2,00	141
19,5	134	—8,5	—0,5	8,0	81,0	1,95	215
20,2	145	—11,0	—2,0	9,0	84,0	2,70	243

An important characteristic of a gas separator is ability to take loads that differ widely with respect to liquid, that is, to work efficiently with a small or large condensate factor. During testing of the gas separator it was learned that the efficiency of separation rises from 93.84 to 99.97 percent as the condensate factor is enlarged from two to 95 grams per cubic meter, and in this case the difference between the dew point and separation temperature decreases (see Table 2 below). The absolute removal of condensate drops from 0.14 to 0.029 grams per cubic meter as the loading is increased for liquid. This is explained by hydrodynamic coagulation of small drops of condensate in the flow part of the separation elements.

Table 2. The Effect of the Condensate Factor on Separation Efficiency with Constant Gas Consumption of 15.2 Million m^2/day (pressure of 52.5 kgf/cm^2)

Condensate Factor g/m^3	Pressure Drop on Separation Plate, mm Water Col	Difference of Dew Point and Separation Temperature, °C	Separation Efficiency, %
2.0	69	2.4	93.84
48.5	93	.1	99.87
95.0	102	0.5	99.97

The separation elements are relatively insensitive to the drop in pressure from loading by liquids. When the loading by liquid is increased from two to 95 grams per cubic meter (almost 50 times), the pressure drop in the separation elements rises from 69 to 102 millimeters water column, that is, only 50 percent. The low hydraulic resistance of the direct flow elements with axial swirlers permits them to be used in a broad range of pressure change, even including vacuum engineering devices.

A significant advantage of the new gas separator is its greater efficiency when the loading by liquid is increased. It follows from this that it would be wise to use the separators in the second stage of separation, not the third. When gas with a low condensate content is being processed the condensate factor should be artificially increased by recycling separated condensate into the initial stream going in for separation. The design of the separator permits this to be done.

No mechanical removal of diethyleneglycol was found in the gas sample, which indicates the high efficiency of diethyleneglycol sepration in the new gas separator.

At the present time two GSV-2400-64 gas separators with axial swirlers have been installed at UKPG-2 and UKPG-5 of the Krestishchenskoye deposit and two first-stage GSE-1000-160 gas separators, also with axial swirlers, have been installed at UKPG-5.

The use of highly productive gas separators with axial swirlers enabled UKPG-2 to combine the gas being sent to the trunk pipelines from 19 parallel working production lines into one flow and remove up to 99.97 percent of the liquid arriving with the gas from it in one unit.

Thus, introduction of the proposed technical decisions provided a significant improvement in the quality of gas preparation, fuller capture of condensate at the fields, a reduction in losses of diethyleneglycol, and an improvement in the work of trunk gas pipelines and compressor plants.

When calculating the annual economic effect the technical-economic indexes of two variations of work for UKPG-2 were compared: without a large unit capacity gas separator and with installation of one such separator with axial swirlers that processes the entire stream of gas being extracted.

Minimum calculated expenditures in the system from the field through the trunk pipeline to the customer was adopted as the criterion of economic efficiency.

The total economic effect of introducing the new gas separator was 328,200 rubles a year, of which 144,400 rubles was at the field and 183,800 rubles in the trunk pipeline.

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FUELS AND RELATED EQUIPMENT

TWO NEW, SMALL REMOTE-SITE GENERATORS DESCRIBED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 p 23

[Article: "Recommended for Introduction"]

[Text] The APES-14 Automated Mobile Power Plant

The APES-14 automated power plant is designed to supply power to the cathode protection stations of the radio relay centers of trunk gas pipelines, as well as for other customers. It may be used both as a primary power source and as a reserve or emergency unit.

The power plant is a container mounted on a sled. Two gas generator motors and one emergency motor that works on diesel fuel are placed inside the container.

The primary sources are 2E-16A diesel generators produced by the Riga Diesel Building Plant converted to work on gas. The power plant has a heating system, which receives its heat from an AGV-120 automatic gas water heater, as well as auxiliary equipment.

The power plant works on natural gas (pressure of 180 ± 20 millimeters water column) and is designed for any clinical [sic] zone of the country. The systems for space heating and engine cooling are combined in a single contour, which makes it possible to maintain normal engine temperature conditions and insures reliable starting. While the AGV-120 is working an above-freezing temperature is maintained in the space and the engines are in a heated condition. When any engine is working the temperature of the chamber and the water in the reserve engine are at a normal level owing to the heat given off by the working engine.

Basic Characteristics of the APES-14

Rated Output, kwt	14
Maximum Output, kwt	15.5
Linear Voltage, v	400

Maximum Output, kwt 15.5
Line Voltage, v 400
Current Frequency, Hz 50
Dimensions of Plant, mm . . . . 6000 × 3200 × 2300
Weight of Power Plant, kg . . . . not more than 9500

The APES-14 power plant went through departmental testing at VNIIgaz [All-Union Scientific Research Institute of Natural Gas] in September 1977 and was recommended for series production this year. The experimental plant of VNIIgaz has shipped eight power plants to the Tyumengazprom [Tyumen' Gas Industry] All-Union Production Association. By the end of the year a total of 17 APES-14's will be manufactured.

Use of the APES-14 at line posts on trunk gas pipelines and other sites (including cultural-domestic facilities) sharply reduces expenditures for energy supply (the need to build power transmission lines and buildings to house emergency power sources disappears).

The economic efficiency of using one APES-14 power plant on a northern gas pipeline is 79,000 rubles a year.

All questions related to purchasing power plants and requests for additional information about them should be sent to the following address: 142700, Moscow Oblast, Leninskiy Rayon, Vidnoye, p. Razvilka, All-Union Scientific Research Institute of Natural Gas.

The 2E-16AG Gas Generator Motor

The laboratory of piston-type gas pumping units at VNIIgaz has developed the 2E-16AG gas generator motor with an output of 16 kilowatts for power supply to cathode protection stations, radio relay centers, and other users on the line parts of trunk gas pipelines. The Riga Diesel Building Plant manufactured an experimental model which was accepted by the interdepartmental commission on 5 April 1979 and recommended for series production. During the current year the Riga Diesel Building Plant, according to the plan of the Ministry of Heavy and Transport Machine Building, is to manufacture 50 gas generator motors this year and to begin producing 100 of them each year starting in 1980.

The need to develop and produce gas generator motors arises because there are no power supply sources or roads in the regions where the principal trunk gas pipelines run and construction of power transmission lines along the pipeline for the current load of the radio relay, cathode protection, and remote control checkpoint systems is economically unwise. It is not advisable to set up diesel generators at line sites either because of the need to deliver liquid fuel and build separate storage facilities and a system for transporting it to the generators.

In terms of output indexes and initial cost the gas generator motors are no different from diesel motors, but their operating costs are much lower.

Experimental industrial testing of the gas generator motors at radio relay stations of the Punga — Komsomol'skiy pipeline (the Tyumentrasnsgaz [Tyumen' Gas Transportation] Production Association) demonstrated their high efficiency and reliability.

The annual economic impact of introducing 100 gas generator motors, according to calculations by the Riga Diesel Building Plant, is 525,000 rubles.

Basic Characteristics of the 2E-16AG

Output, kwt	
100%	16
110%	17.6
Current Frequency, Hz	50
Line Voltage, v	400
Specific Expenditure of Natural Gas at Rated Output, gcal/kwt·hr	3,449
Specific Expenditure of Oil at Rated Output, g/kwt·hr	2.23
Weight of Generator Motor, kg	685 ± 3%
Inclination of Control Characteristics, %	4.5
Overrun of rpm's When Dropping and Picking Up 100 Percent of Load, %	6
Duration of Switching Process, sec	5
Starting Time with Air Temperature at Suction of + 8°C, sec	10
Dimensions, mm:	
Length	1,385
Width	685
Height	1,250

All requests for additional information may be sent to the following addresses: 226005, Riga, Ulitsa Ganibu Danbis, 40, Riga Diesel Building Plant; 142700, Moscow Oblast, Leninskiy Rayon, Vidnoye, p. Razvilka, All-Union Scientific Research Institute of Natural Gas.

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FUELS AND RELATED EQUIPMENT

SHORT BIOGRAPHY OF EMMA GEORGIYEVNA ODINTSOVA

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 10, Oct 79 p 49

[Article: "Anniversary Page"]

[Text] The people who work at the Ministry of the Gas Industry were greatly pleased to receive the news that Emma Georgiyevna Odintsova, chief of the ministry's Administration for Full Equipment Supply, was awarded the title "Honored Employee of the Gas Industry."

The Board of Directors of the Ministry of the Gas Industry and the Presidium of the Central Committee of the Trade Union of Oil and Gas Industry Workers awarded this lofty title to E. G. Odintsova for her great personal contribution to the development of the gas industry and in connection with her 50th birthday.

Emma Georgiyevna has a long career in labor. After graduation from a tekhnikum in 1951 she took a job as senior console operator at the Kamenskiy central heat and electric power plant, where she showed herself to be an energetic and enterprising worker. In 1953 E. G. Odintsova went to work at the Novocherkassk Machine Building Plant imeni A. A. Nikol'skiy, after which she was employed at enterprises in Moscow Oblast. Emma Georgiyevna has successfully handled the broad and demanding duties of electrical engineer and chief of an electrical grid region.

E. G. Odintsova joined the ranks of the Communist Party of the Soviet Union in 1961. She was given more important work, which only added to her vigor and confidence. In her everyday working life the young communist E. G. Odintsova followed the principle expressed in the words of the great Lenin: "We must strive with all our might and watch as closely as possible to see that we follow the party in word and in deed."

E. G. Odintsova worked heroically, as hard as she could,while studying constantly and improving her technical, political, and scientific background. She graduated from the Moscow Institute of the Petrochemical and Gas Industry imeni I. M. Gubkin without disrupting her primary activities. In 1955 she went to work at the Soyuzgazkomplekt [USSR Complete Gas Equipment] Trust of the Ministry of the Gas Industry, serving at first as chief mechanical engineer and then as technical manager. It was there that she showed her unusual talent as a leader, one on whom the successes of production depend significantly.

Energy and initiative combined with profound knowledge and high party principle have always typified the activities of Emma Georgiyevna Odintsova in her positions as chief engineer and deputy head of Glazgazkomplektoborudovaniye [Main Administration for Supply of Complete Sets of Gas Equipment] of the Ministry of the Gas Industry (1969-1972), deputy chief-chief engineer, and then head of the Administration for Full Equipment Supply.

For her productive, heroic labor E. G. Odintsova has been awarded the Badge of Honor and various medals.

The award of the title "Honored Employee of the Gas Industry" is a worthy tribute to her on this anniversary.

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